EVALUATING RESIDENTIAL WATER CONSERVATION ATTITUDES, BEHAVIORS, AND DEMAND MANAGEMENT POLICY EFFECTIVENESS IN COLLEGE STATION, TX

A Dissertation

by

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ABSTRACT

In the residential sector managing scarcity requires a shift in patterns of household water use. Voluntary instruments that rely on persuasion and information are some of the most commonly used methods adopted in an effort to change consumer attitudes and behaviors. However, the efficacy of these instruments remains poorly understood. In this dissertation I evaluate the efficacy of an information-based demand management program. This research is based on three questions. 1) Has the program been successful in changing attitudes toward complying with the conservation behaviors that it advocates, and are those attitudes predictive of compliance? 2) What factors lead to the internalization of a personal norm to conserve community resources, and does it result in reduced water use? 3) Has the program been successful in changing patterns of water use, and how have those patterns of water use changed over time?

To address research question one I test the relationship between an intention to comply with the persuasive program and subsequent water use drawing on the integrated model of behavioral prediction. Results indicate that the program was successful in creating positive attitudes toward conservation and that those attitudes predict compliance. To answer research question two I draw on the norm activation model. I hypothesize an extended model that incorporates community attachment as a predictor of personal norms, and contextual factors as predictors of outdoor water use. Results indicate that community attachment is a significant predictor of personal norms and that a personal norm to conserve water is negatively related to water use controlling for contextual factors. I develop a quasi-experimental design to answer research question three. I use a difference-in-difference approach to determine the effects of the persuasive program on actual water consumption over time for households that received the persuasive messages and those that did not. Results indicate that the program had a negative influence on water use and the treatment effect gets stronger over time. However, the treatment effect varies as a function of baseline water use. This work has implications for both the theory of attitude-behavior correspondence, and the practice of managing residential demands for water.

DEDICATION

This dissertation is dedicated to my parents Dawn and Steve Landon, my grandmothers Mary Robbins and Lorraine Elliott, my brother Owen Landon, and remaining family and friends. Without your love and support this would not have been possible.

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CHAPTER I

INTRODUCTION

Water scarcity is an increasingly salient issue the world over. Human population growth, climate change, and rising standards of living influence both the supply of freshwater and per capita demands for the goods and services that require it (Richter 2014). Supplying water to meet human needs in the face of these drivers of change is a continual challenge for municipal water managers (Rockström et al. 2014; Postel and Richter, 2003).

Traditionally, when water managers are faced with a need to provide water for a greater demand than they are currently able to supply, they have sought to expand the capacity of the water systems that they operate to pump, store, and distribute water (Thompson 1998). However, expanded extractions of surface and groundwater are often infeasible given the physical limits of supply, needs of the environment, and demands placed on the resource from other stakeholders (Gleick 2000). Supply side expansions in reservoir and well-field development are often met with political opposition due to their high financial costs and the impacts that they have on these and other areas of social, political, and environmental concern (Gleick 2000).

Consequently, demand management has emerged as an alternative paradigm for managing water scarcity in the municipal water sector (Fielding et al. 2012; Brooks 2006). Rather than increase real supply through the acquisition of new water from the environment, demand management seeks to alter the attitudes and behaviors of municipal water customers, and improve the efficiency of delivery of the current water system in order to meet new demands (Brooks 2006).

Over the last several decades a number of municipalities in the State of Texas – and elsewhere - have adopted demand management as method to help mitigate water scarcity. Managers have implemented a variety of policy instruments in an attempt to accomplish these goals (Kenny et al 2008; Renwick and Green 2000). Some of the most commonly used instruments include conservation pricing (Olmstead and Stavins 2009), incentives for technical retrofits (Renwick and Green 2000), regulatory requirements (Kenney et al. 2008) and public education and information campaigns (Syme et al. 2000). Although the efficacy of market-based instruments and incentives for efficiency upgrades have been explored extensively in the literature, the ability of voluntary information-based programs to affect consumer attitudes and water use behaviors are less well understood (Syme et al. 2000; Michelsen et al. 1999).

In the City of College Station water managers have undertaken an ambitious information-based educational campaign in an effort to change resident's attitudes toward conservation, and increase the efficiency of outdoor water use among the city's most prolific water users. Specifically, this program has provided households with feedback information on their outdoor water use along with comparisons of that water use to that of their neighbors, and an efficient standard of irrigation application; as well as tips on how to conserve. Collectively this information is referred to as a "water budget".

In this dissertation research I examine the efficacy of this information-based persuasive program in changing consumer attitudes, the relationship between those attitudes and complying with the recommendations of the water budget, and the ability of the program to change residential water use over time. This research adds to a growing body of literature on residential water conservation policy evaluation (Ferraro and Price 2013; Syme et al. 2000) and attitude-behavior relationships drawing on theory from conservation psychology (Fishbein and Ajzen 2010; Schwartz 1977). Consequently, the insights gleaned from this work are intended to inform both the implementation of residential demand management policy, and further refine knowledge of the utility of attitude based theories of human behavior within the realm of residential water use (Jorgensen et al. 2009).

The research presented here is structured in three primary chapters. In chapter II I test a predictive model of compliance with the water budget program drawing on the integrated model of behavioral prediction (Fishbein and Ajzen 2010). In Chapter III I explore the broader relationship between consumer water conservation attitudes and outdoor water use drawing on Schwartz's (1977) Norm Activation Model as a guiding framework. Finally, in Chapter IV I develop a quasi-experimental framework to test the ability of the water budget program to affect a change in residential household water use. In this chapter I also explore variability in the treatment effect of the water budget over time and as a function of baseline water use.

CHAPTER II

PREDICTING COMPLIANCE WITH A RESIDENTIAL OUTDOOR WATER CONSERVATION PROGRAM

Demand management has become an important component of sustainability initiatives in the municipal water sector (Fielding et al. 2012; Bates 2008; Brooks 2006). In addition to conservation pricing (Olmstead and Stavins 2009), restrictions on water use (Kenney et al. 2008), and financial incentives for upgrading less efficient technologies (Renwick and Green 2000), many utility-led demand management programs involve some form of public education or persuasion aimed at altering the attitudes and behaviors of municipal water customers (Syme et al. 2000). Many of these programs have been targeted at outdoor water use given that it constitutes a significant proportion of total household consumption (Arbúes 2003), is often highly inefficient, and seen as non-essential for meeting basic human needs (Hilaire et al. 2008). The Environmental Protection Agency (2013), for instance, estimates that as much as half of all water used for residential landscaping irrigation in the United States is wasted due to leaks, misdirection, and over-application.

As a function of these concerns, and a need to meet rising demands from a growing residential population, water managers in College Station, Texas, have undertaken a campaign to increase the efficiency of outdoor water use in their service area. A key component of this program has involved the dissemination of persuasive communications to a subsection of the city's largest water users. Termed a "water budget", the persuasive communications provide consumers with comparisons of their outdoor water use to an efficient standard, the water use of their neighbors, and provide recommendations for reducing water use. The efficiency standard – from here forward "water budget" - represents how much outdoor water a given household should have consumed if they were using outdoor water efficiently while keeping it alive and green. Providing consumers with feedback on their outdoor water use is intended to encourage them to use water in an efficient manner and change their attitudes toward conservation.

However, the ability of persuasive instruments like the water budget to bring about a change in residential water use vary as a function of constituent attitudes toward the behaviors that they promote, and the social and environmental contexts in which they occur (Seyranian et al. 2015; Treizenberg et al. 2014; Dillard and Shen 2013; Fishbein and Ajzen 2010). It is necessary to understand residents' attitudes toward water conservation behaviors encouraged through persuasive communications and the environmental factors that facilitate and constrain their adoption in order to evaluate the efficacy of associated demand management initiatives (Monroe 2003). Knowledge of these factors will provide mangers with the information needed to determine alternative courses of intervention, improve the sustainability of municipal water systems, and reduce impacts on source ecosystems and groundwater basins. In the present study we examine the relationship between residents' attitudes toward complying with the water budget (e.g. using less water than it calls for), the relationship between attitudes toward the water budget and compliance, and the environmental factors that facilitate and constrain the efficient use of outdoor water.

Literature Review

To conceptualize the process through which the water budget communications ultimately influence compliance, we draw on the integrated model (IM) of behavioral prediction (Fishbein and Ajzen 2010; Fishbein 2000; Fishbein and Yzer 2003). The IM, along with its predecessors, the theory of reasoned action (TRA) and theory of planned behavior (TPB), is one of the most widely used psychological theories of individual behavior (for a review see Armitage and Conner 2001; Fishbein and Ajzen 2010 - and in the water context Russell and Fielding 2010). The theory has had wide appeal in applied contexts like residential water use given its relative parsimony (Fishbein and Ajzen 2010; Russell and Fielding 2010). Broadly speaking, the IM hypothesizes that an intention to perform a behavior is the most proximal antecedent to its performance. Behavioral intentions are in turn a function of attitudes toward the outcome of carrying out the behavior, beliefs concerning the expectations of one's peers related to the behavior, and the extent to which the behavior is under the volitional control of the individual in question (Ajzen 1991; Eagly and Chaiken 1993). Perceived behavioral control (PBC) - or perceived self-efficacy - can have a direct effect on behavior when the measure of PBC is a close approximation of actual control (Hardeman et al. 2002; Kaiser et al. 2003). Behavior change in the IM is hypothesized to occur indirectly through changes in attitudes, normative beliefs, and beliefs concerning one's self-efficacy in carrying out the behavior. Positive evaluations of behaviors advocated by persuasion can lead to the formation of an intention that ultimately translates into compliance (Eagly and Chaiken 1993; Petty and Cacioppo 1986). To that end, the water budget program is a persuasive effort intended to foster positive attitudes toward water conservation, positive beliefs concerning water conservation behaviors in the broader community, the skills and knowledge needed for one to comply, and ultimately an intention to do so.

A number of factors, however, may influence the extent to which a given behavior is under actual volitional control (Eagly and Chaiken 1993). Although a persuasive communication like the water budget might be successful in developing a positive intention to perform a given behavior, an individual may not be able to translate that intention into action (Kollmus and Agyeman 2002). Consumer choice is constrained by a variety of social, cultural, political, and physical characteristics of the systems in which individuals are embedded (Lutzenhiser 1993). The "ABC" model suggests that behavior (B) is a function of both attitude (A) and the context (C) in which it occurs (Guagnano et al. 1995). When contextual factors exert a significant influence on behavior, the attitude-behavior relationship can be quite small (Stern et al. 1999; Stern 2000). Therefore, the performance of water conservation behaviors that are often complex, costly in terms of time, and limited in terms of financial incentive, are a function not only of cognitive processes like those modeled through the intention-behavior relationship but are shaped by the broader social, institutional, and environmental context in which they occur (Black et al. 1985). In addition to attitudes, each of these variables represents a potential lever for managers to manipulate in order to achieve a change in water use behavior among their constituents. Behavioral change requires both a positive evaluation of the attitude object (water conservation) and an absence of barriers that can potentially impede its performance (Kollmus and Agyeman

2002; Stern et al. 1999; 2000; Guagnano et al. 1995). The question remains, however, which variables are the most salient for managers to target for intervention, attitudes or environmental contextual factors? Results from this study inform managers which of these “levers” they need to pull to promote conservation among their constituents and evaluate the efficacy of their persuasive efforts.

The Integrated Model and Water Conservation Behaviors

The IM - and other progenitors of the theory - has been a guiding framework in many investigations of water conservation intentions and behaviors. Trumbo and O’keefe, (2001; 2007), for example, drew on the theory of planned behavior in their investigation of water conservation intentions among residential water users, finding support for the applicability of the theory in explaining intentions to reduce water use. Lam (2006) also used the TPB to predict intentions to engage in water conservation behaviors among Taiwanese utility workers. Clark and Finely (2007) drew on the TPB as well as general environmental attitudes and concern, and socio-demographic characteristics to explain water conservation intentions in their study of Bulgarian residential water customers. In their work they found that in addition to the relationships hypothesized by the TPB that general environmental attitudes, environmental concern, and socio-demographic characteristics were significantly correlated with intentions to conserve water. Yazdanpanah et al. (2014), examined water conservation behaviors adopted by famers in Iran. In their analysis they found that an intention to engage in water conservation actions was significantly correlated with self-reported conservation behaviors. While these studies have advanced our understanding of the social psychological factors that drive the public's intent, they have fallen short of demonstrating the theory's ability to account for actual behavior; that is, where behavior is objectively measured.

In fact, the few studies that have examined the relationship between metered water use and conservation intentions have reported relatively weak associations between intention and behavior. For example, Fielding et al. (2012) found that curtailment intentions were not a significant predictor of metered water use among residents in Australia. Similarly, Jorgensen et al. (2014), in addition to expressing concerns over the applicability of individual theories of behavior in accounting for household water use, reported a weak relationship between an intention to conserve and future water use. Armitage and Conner (2001) in a review of the TPB across all fields of application found that studies using observed behavior measures reported a weaker intention-behavior relationship compared to those relying on self-reports.

These findings suggest that there may well be other factors driving water use beyond consumers' intention to conserve and their perceived self-efficacy for doing so. Outdoor water use may not be entirely volitional as the institutional landscape and infrastructural and individual characteristics of the home and household have the potential to constrain the adoption of conservation behaviors (Jorgensen et al. 2009). For the individual, changing outdoor water use behavior can be costly given the time required to learn methods of conservation in addition to the expense of installing new technologies (Yakibu et al. 2008). Also, the financial incentives for engaging in conservation can be small when the marginal price paid for water is low (Olmstead and

Stavins 2009). Therefore, a number of potential barriers may constrain the adoption of water conservation behavior like those advocated by the water budget program, even if it is successful in creating positive attitudes toward compliance (Kollmus and Agyeman 2002; Costanzo et al. 1986).

Several scholars have proposed interdisciplinary models that combine psychological and environmental contextual factors to explain patterns of residential water use stressing that psychological factors alone are insufficient for explaining water use behavior (Jorgensen et al. 2009; Syme et al. 2004; Russel and Fielding 2010; Gregory and Di Leo 2003). In the section to follow we summarize past work that has examined the relationship between environmental contextual factors on outdoor water use including household infrastructure and characteristics and the institutional landscape, and hypothesize how they relate to compliance with the water budget.

Neighborhood of Residence

Institutions both formal and informal have the potential to influence household water consumption (Larson et al. 2009; Ostrom 2007). Home owners associations (HOA) can implement formal rules that govern landscaping choice in an attempt to maintain a common aesthetic and protect property values (Turner and Ibes 2011; Larson et al. 2009; Nassauer et al. 2009; Cook et al. 2012). These rules may ultimately influence outdoor water use (Turner and Ibes 2011). Many HOAs have the ability to fine residents for non-compliance. The coercive penalties associated with non-compliance have the potential to incentivize over use (Turner and Ibes 2011). Even if homeowners possess positive attitudes toward conservation, HOA requirements may constrain them from acting on them for fear of externally imposed sanctions (Turner and Ibes 2011; Nassauer et al. 2009).

Helmke and Levitske (2004) define informal institutions as the "…socially shared rules, usually unwritten, that are created, communicated, and enforced, outside of officially sanctioned channels". Social norms for landscaping design are an example of an informal institution that is relevant for understanding outdoor water use. Nassuaer et al. (2009) explored the role of social norms in landscaping choice. They found that normative expectations can have a dramatic impact on choices for outdoor landscaping and, therefore, water use. Similarly, Hurd (2006) demonstrated variation in landscaping choice across communities in New Mexico pointing to differences in culture as the cause. These studies, and others, suggest that choices of landscaping and water use are influenced by both formal structures like rules enacted by specific HOAs, and informal structures like social norms that exist within a given neighborhood or community.

Given this, we hypothesized that, controlling for other factors, neighborhood membership would have a significant influence on compliance with the water budget as different HOAs are governed by different requirements for landscaping and neighborhoods potentially have different social normative expectations for landscaping and water use (Larson et al. 2009; Nassauer et al. 2009). These differences will result in some neighborhoods using water more efficiently than others.

Income and Household Infrastructure

Harlan et al. (2009) examined the role of affluence on outdoor water use. They hypothesized that the possession of larger homes, irrigated landscaping features, and water using infrastructural elements including swimming pools and fountains reveal a preference for a “water intensive lifestyle”. The possession of these infrastructural elements is driven by a desire to use water in order to obtain other benefits such as family recreation and to display social status (Harlan et al. 2009. Income provides the mechanism to fulfill these preferences for water use. Higher income households are less subject to budget constraints as they relate to the water bill. The costs of water represent a very small proportion of monthly income for higher earning households (Arbúes et al. 2003). Wealthier consumers have shown lower sensitivity to price and are less inclined to comply with voluntary and coercive water use restrictions imposed by utilities during periods of acute water scarcity (De Oliver 1999). Therefore, income and the possession of water consuming infrastructure may influence compliance with the water budget. Although consumers may develop an intention to comply with the behaviors advocated by the conservation program, the benefits that the individual derives from the use of water may override them. Additionally, the financial incentives to conserve may be so small that they are irrelevant to water use decisions in higher income households. Consequently, we hypothesized that income would have a negative effect on compliance with the water budget. Additionally, water using infrastructural elements including pools, ponds, fountains, and irrigated landscaping features will have a negative influence on compliance with the water budget as these infrastructural elements are responsible for water use that is not accounted for in the water budget.

Lawn Area

The majority of household water consumption in the Western United States is for lawn and landscaping irrigation (Hilaire et al. 2008; Thompson 1999). Therefore, the area of the lawn subject to irrigation is possibly the most relevant environmental contextual factor influencing outdoor water use and, consequently, compliance with the water budget. Generally speaking, the larger the lawn, the more water the household will consume. Syme et al. (2004), for example, found that the area of lawn was a significant predictor of outdoor water use. The water budget, however, is adjusted to account for lawn area. The water budget represents an "efficient" use of water over a given area of lawn. Past observations of outdoor water use among these households leads us to suspect that water over use is negatively associated with the area of lawn subject to irrigation. Households with smaller lawns, although using less water, overall, are more likely to use more water than is efficient than are households with larger lawns given the larger total volume of water consumed. The monthly costs of inefficient water use are higher for a larger area of lawn than they are for a smaller one. Additionally, the area of lawn assumed to be under irrigation is likely less accurate with larger lots. Thus, we hypothesized that the area of the lawn subject to irrigation is negatively associated with compliance with the water budget. Households with smaller lawns will use water less efficiently than larger ones.

Age of the Home

Last, the age of the home has been shown to influence outdoor water use. Older homes have less technologically advanced infrastructure that runs a higher risk of developing leaks over time (Mayer et al. 1998). Older homes, however, have more well developed vegetation with taller trees. The more shade that the household has cast over the lawn the less evapotranspiration occurs and, consequently, the lower the demand for water. Due to these competing factors we were unable to construct specific hypothesis on the directionality of the influence of home age on compliance with the water budget. However, these influences do suggest that it is an important variable that should be accounted for. Home age may constrain positive attitudes toward compliance given that unknown water leaks may undermine conservation efforts. Alternatively, characteristics of the landscape that reduce water requirements, like shade and more deeply rooted vegetation, may facilitate positive intentions to comply as the lawn has lower water requirements.

The Current Study

Our study differs from previous research in the residential demand management literature that has drawn on the IM - and other earlier derivatives of the theory - in that we have presented our study participants with a persuasive message, measured attitudes and intentions to comply with the behaviors that it advocates, measured environmental contextual variables that may influence compliance, and measured subsequent water use behavior. Much of the past research in this area has measured only general water conservation attitudes. Also, few psychological studies of residential water conservation have used objective behavioral measures relying instead on behavioral intentions and self-reports while ignoring facilitating and constraining environmental factors (Jorgensen et al. 2014; Russell and Fielding 2010). We add to this literature by testing the utility of the IM in predicting objective behavior in the context of residential water use, demonstrating the potential for personalized feedback information in shaping water conservation attitudes, and the role of the environmental context in affecting water use and conservation.

Hypothesized Model

Figure 1 is a graphical representation of the hypothesized relationships that constitute the psycho-behavioral process influencing compliance with the water budget. Drawing on the IM, we hypothesize that compliance with the water budget is a function of an intention to comply, perceived self-efficacy for doing so, and the environmental contextual factors that facilitate and constrain compliance. Intentions are in turn a function of perceived self-efficacy, beliefs concerning the expectations of one’s peers related to compliance with water budget, and beliefs about the outcome of complying with the water budget. We hypothesize that - controlling for other factors - those that have a higher intention to comply with the water budget will use outdoor water more efficiently. Similarly, those that have a stronger belief in their ability to comply with the water budget will use outdoor water more efficiently. Additionally, we hypothesize that a number of environmental contextual factors will have a direct effect on compliance with the water budget including; neighborhood of residence, market value of the home (income), irrigable area of lawn, possession of a pool, garden, and pond, age of the home, and number of irrigated landscaping features other than the lawn. In the section to follow we present the methods used to test these hypotheses beginning with a description of the context in which this study was conducted.

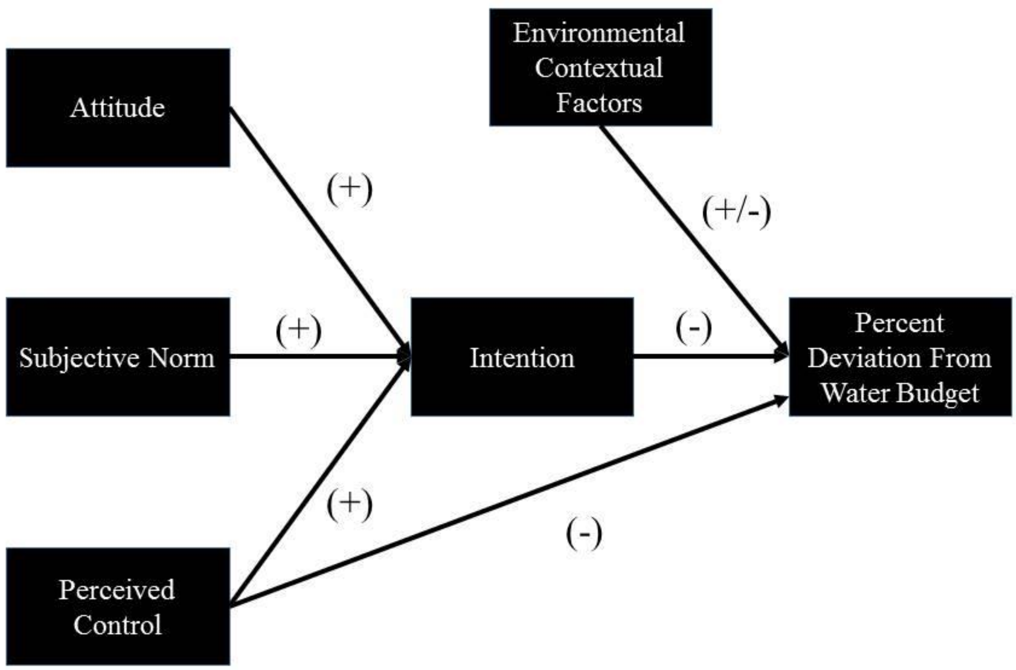

Figure 1. Generalized hypothesis depicting the psycho-behavioral process influencing compliance with the water budget.

Method

Study Context

As of 2013, the U.S. Census estimates that the population of College Station is roughly 100,000 people. Municipal planning entities expect that the city's population will grow substantially over the next several decades (City of College Station 2010). Consequently, it is projected that by 2030 demand for water will exceed current supplies, and by 2060 the city will have an annual water need of around 6,000 acre/ft (TWDB 2012). Therefore, conservation has become a major component of city water planning initiatives. The city relies exclusively on groundwater for municipal supply. Although the city possesses the capacity to expand pumping to meet these needs, conservation is the preferred alternative given that it is more cost effective, reduces environmental impact, and preserves supply for future needs (Gleick 2000). Within the service area, 5,565 households account for roughly 40% of the annual water use. These households, however, represent only 15% of the total water accounts. The majority of water use within this group is for outdoor purposes, specifically lawn and landscaping irrigation. Therefore, the outdoor water use of this group has been the subject of much of the conservation effort in the city. This population is the focus of the current investigation. These households received the water budget communications at the beginning of the irrigation season – April to October - each year since 2012.

The Water Budget

Determining what constitutes an acceptable level of outdoor water use has been a difficult policy question for municipal water managers. Concerns over equity (Sanvenije and van der Zaag 2002), autonomy of residents in choosing how much water to consume, and the appropriateness of mangers influencing the behaviors of private citizens have prompted utilities to seek metrics of efficiency that are rooted in objective natural phenomena. The water budget, and other similar conceptualizations, has gained traction as one such metric (Baerkenlau et al. 2013). The water budget is derived from a monthly water balance of evapotranspiration and precipitation as it relates to lawn water needs over a given area. The water budget, therefore, represents an "efficient" use of water. Water used in excess of the budget is above how much one needs to use in order to maintain their lawn in a healthy living condition. Encouraging an efficient use of water is seen by many utilities as a neutral position on water use and, therefore, more defensible in the political arena; but may still yield a desired reduction in residential water use if managers can persuade constituents to conform. Monthly water budgets are calculated from the following equation:

$$\text{WB (gal)}_{\text{month}} = \text{Irrigable Area (ft}^2\text{)} * [(K_c * \text{PET (in)} - \text{P (in)})] * .6\ (\text{gal/ft}^2)$$

Where WB is the monthly water budget in gallons, Irrigable Area is the square footage of lawn within a residential parcel subject to irrigation, K_c is a crop coefficient used to account for the dominant vegetation type in the city (assumed to be St. Augustine grass uniformly), PET is the monthly potential evapotranspiration in inches taken from weather station measurements, P is precipitation in inches, and .6 is a constant conversion factor (ft^2 to gallons). County tax assessment records were used to calculate irrigable area. Irrigable area is assumed to be a function of the total parcel area of the household in square feet less the footprint of buildings and the driveway. Shapefiles containing parcel boundaries, and building and driveway footprints were obtained from the City of College Station. PET and precipitation data were obtained from the TexasET Network station at the Texas A&M Turfgrass research facility in College Station. Average monthly January through February water use was calculated for each household and subtracted from the monthly irrigation season water use to account for indoor consumption. Because the vegetation planted in the city becomes dormant in the winter and does not require irrigation, the vast majority of winter use occurs indoors. This makes winter use a good approximation of indoor water use in the summer months, and is commonly used in studies of residential outdoor water use (Syme et al. 2004). For households that had outdoor water use less than their average winter use during a given month their outdoor water use was set to 0. For months where precipitation exceeds evapotranspiration the water budget is set to 0.

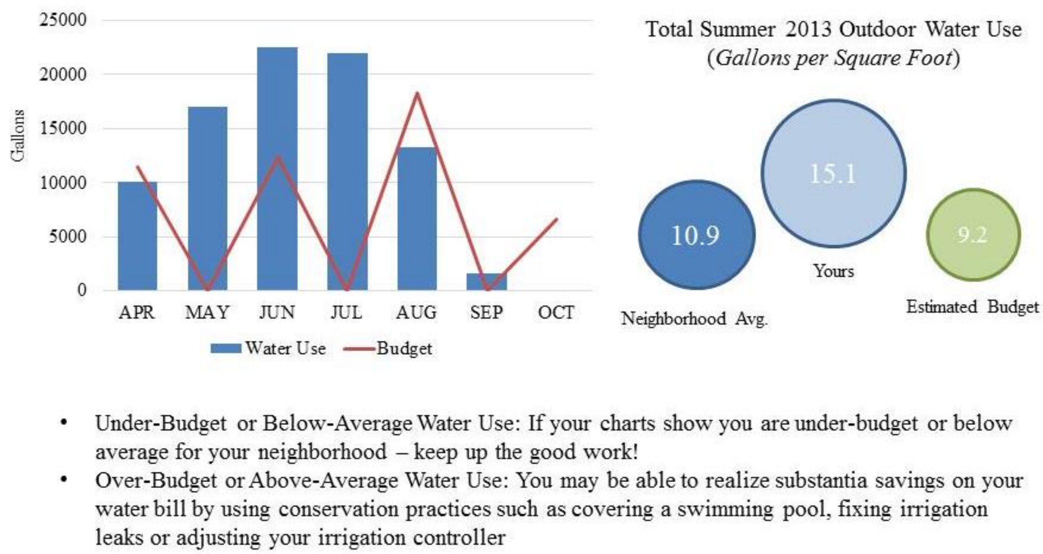

Figure 2. Example water budget communication

An example water budget presented to study participants in 2014 is shown in Figure 2. The blue bars are monthly outdoor water use during the 2013 irrigation season. The red line is the monthly water budget calculated following the method described above. In addition to the feedback information provided on outdoor water use, the communication contains a comparison of outdoor water use to the average outdoor water use of the neighborhood, a normative statement about their behavior, and tips on how to conserve. Providing the water budget to consumers is intended to create positive attitudes toward compliance and beliefs concerning the appropriateness of conforming to the water budget in the social arena. Social normative comparisons have been shown to have significant impacts on behavior (Schultz et al. 2014; Cialdini et al. 1990). It is through these mechanisms that attitudinal and behavioral change is hypothesized to occur. Along with the water budget itself consumers receive a cover letter signed by the city water manger that explains the intent of the project and directs them toward online resources for conservation provided by the city.

Measures

Intention, attitude, subjective norm, and perceived behavioral control items were measured at the same level of specificity as they relate to time, attitude object, and context (Fishbein and Ajzen 1977). Attitude was measured using two items; "Staying within my water budget is a positive thing" and "It is important to stay within my water budget". These measures reflect beliefs about the outcome of the attitude object, in this case using less water than the water budget calls for. Subjective normative beliefs were also measured with two items: "People important to me think I should stay within my water budget" and "People like me should stay within their water budget". Perceived behavioral control and intention were measured with two items "I can control whether or not I stay within my water budget" and "I intend to stay within my water budget," respectively (Fishbein and Manfredo 1992; Fishbein and Ajzen 2010). These variables were measured on a five point Likert type agreement scale where 1=Strongly Disagree and 5= Strongly Agree. Item parcels were created from the two questions each measuring attitude and subjective norm (Little et al. 2002). Both constructs displayed adequate internal consistency with Cronbach's alpha greater than .7 (Nunally and Bernstein 1994).

Monthly household water use was taken from water meter readings obtained from the City of College Station Utilities Water Services Department. Behavior was operationalized as percent deviation from the water budget for the 2014 irrigation season. The water budget was subtracted from outdoor water use for each month, summed, dived by the total water budget, and multiplied by 100 to obtain percent deviation for the irrigation season. Positive values indicate water use in excess of the budget and negative values indicate water use below the water budget. A value of zero would indicate water use exactly at the budget. Deviation from the water budget ranged from a low of -100% to a high of 343%. Using the water budget as a measure of efficiency, our operationalization of behavior can also be interpreted as outdoor water use efficiency with higher values representing a less efficient use of water. Nine households in the sample had dedicated water meters for their sprinkler systems. For these households only this amount was used as a measure of outdoor water use.

Environmental contextual variables were operationalized from a combination of survey results and data taken from the publicly available Brazos County Appraisal District GIS database (BCAD 2013). Households in the study reside in 12 different neighborhoods. In College Station HOAs exist at the neighborhood scale. Additionally, social normative comparisons of water use were provided to consumers by neighborhoods. These neighborhoods vary in terms of size, location, and HOA rules governing landscaping features and water use. To operationalize neighborhood effects we constructed a set of dummy variables for each of the 12 neighborhoods in the study where 1= household is located in that neighborhood and 0=household is not located in that neighborhood. We refer to this collective set of dummy variables as “neighborhood of residence”. Market value of the home was used as a proxy for household income (Tinker et al. 2005). We operationalized household characteristics with seven measures including; “Irrigable Area” (ft^2); possession of a pool, “Has Swimming Pool” (1=yes, 0=no); “Home Age” (years); possession of a vegetable garden, “Has Garden” (yes/no); possession of a pond or fountain, “Has Pond or Fountain” (yes/no); and “Number of Irrigated Landscaping Features” other than the lawn (#). Descriptive statistics for the measures described above are presented in Table 1.

Table 1. Descriptive statistics for IM attitudinal variables, environmental contextual factors, water use and deviation from water budget

Variables	*M*	*SD*
Core IM Variables		
Attitude	4.14	.71
Subjective Norm	3.74	.72
Perceived Behavioral Control	3.91	.90
Intention	4.10	.74
Environmental Contextual Factors		
Irrigable Area	9,299	406
Market Value	228,356	5915
Has Swimming Pool (%)	8.49	-
Home Age	20.4	10.86
Has Vegetable Garden (%)	22.6	-
Has Pond or Fountain	11.34	-
Number Irrigated Landscaping Features	3.03	3.01
Neighborhood of residence	-	-
Water Use and Water Budget		
April – October Outdoor Water Use	70,420	56,020
January – February Winter (Indoor) Water Use	11,088	7,177
Water Budget	60,775	41,264
Percent Over Budget	23.97	80.92

Survey Data Collection

Of the 5,565 households that were sent the water budgets, 2,500 were randomly selected to receive a survey questionnaire. Questionnaires were administered through postal mail following a modified version of the Dillman tailored design method (Dillman et al. 2009). Four contacts were used to solicit responses: 1st) A letter describing the purpose of the study was sent along with the water budget; 2nd) Two weeks following the mailing of the water budgets, survey packets containing a cover letter, survey questionnaire, and prepaid return postage were sent to participants; 3rd) One week after the mailing of the initial survey packet a follow up reminder/thank you postcard was sent to non-respondents; and 4th) One week after the mailing of the postcards a second survey packet with cover letter, questionnaire, and pre-paid return envelope was sent to non-respondents. Data collection took place during the period May to August 2014. Collection efforts yielded 654 usable surveys for an effective response rate of 26%. Checks for non-response bias yielded no significant mean differences in total water use, lot size, home value, or age of the home between survey respondents and non-respondents leading us to conclude that the sample is representative of the larger population of interest.

The socio-demographic profile of the sample is not characteristic of the population of College Station, but consistent with the profile of the City's most prolific consumers of outdoor water. On average study participants were 58.1 years old and predominantly male (62%). Participants were highly educated with greater than 50% completing a Master's degree. On average respondents have resided in their current homes for 11.1 years, with an average assessed value of $228,356. Average irrigable parcel size was 9,299 ft^2. Mean January through February water use was 11,088 gallons, compared to 70,420 gallons for the 2014 irrigation season. However, water use is highly variable across the sample.

Analysis and Results

Description of Analysis

We conducted our analysis in two stages. First we regressed intention to comply with the water budget on attitude, subjective norm, and perceived behavioral control using OLS regression in STATA version 14 (StataCorp 2015). Results for this model predicting intention are presented in Table 2. Next we regressed behavior, operationalized as percent deviation from the water budget, on three blocks of independent predictors. The first block was composed of the core IM variables measuring intention, attitude, subjective norm, and perceived behavioral control. The second block of predictors included the IM variables in addition to environmental contextual factors including: irrigable area, market value (income), has pool, home age, has vegetable garden, irrigated landscaping features, and has pond or fountain. In the final model we retained the IM variables and environmental contextual factors from blocks one and two, and added the set of dummy variables controlling for neighborhood of residence. Results for models predicting deviation from the water budget are presented in Table 3. We chose this approach in order to examine changes in the variance explained in behavior and strength of IM variable coefficients predicting behavior as they were potentially mediated by environmental contextual factors and neighborhood of residence (Baron and Kenny 1986).

Results from model 1 indicate that attitude (β = .54, p <.001) and subjective norm (β=.33, p<.001) were significant predictors of an intention to comply with the water budget. Perceived behavioral control (β = .06, p <.05), although significant, was weakly associated with intention. Collectively, these three predictors accounted for 71% of the variance in intention.

Table 2. Summary of effects for model predicting intention to comply with the water budget

Variable	β	*SE*
Attitude	.54***	.04
Subjective Norm	.33***	.03
Perceived Behavioral Control	.05**	.11
R^2	.71	
N	603	

*p≤.10, **p≤.05, ***p≤.001

In model 2, we first regressed percent deviation from the water budget on intention, perceived behavioral control, attitude, and subjective norm. The results partially confirm the hypothesized theoretical structure of the IM. Intention (β = -.22, p <.01) was significantly and negatively related to deviation from the water budget. Those that intended to comply with the water budget were more efficient in their use of outdoor water. Consistent with the theory, attitudes and subjective normative beliefs did not have a direct relationship with behavior. Although perceived behavioral control was hypothesized to have a direct effect on behavior we did not find support for that relationship. Intention, perceived behavioral control, attitude and subjective norm accounted for a small proportion of the variance in deviation from the water budget (R^2 = .02).

Next we regressed behavior on environmental contextual factors while retaining the IM variables from block 1. The results indicate that after controlling for environmental contextual factors the variance explained in percent deviation from the water budget increased substantially (ΔR^2 = .19). After the inclusion of household infrastructural factors the intention-behavior relationship remained significant although the strength of the relationship decreased slightly (β = -.18, p <.01). Irrigable area (β = -.27, p <.001) and market value (income) (β = .26, p <.001) were revealed to be the strongest predictors of percent deviation from the water budget. Households with a larger irrigable area used outdoor water more efficiently. Conversely, households with higher market values (incomes) used outdoor water less efficiently; consistent with our hypotheses. In addition to these two variables, home age (β = -.15, p <.001), possession of a pond or fountain (β = .13, p <.01), and the number of irrigated landscaping features other than the lawn (β = .13, p <.01) all had a significant influence on outdoor water use efficiency. Older homes used outdoor water more efficiently than newer ones. Households possessing water intensive infrastructure including irrigated landscaping features and ponds/fountains used outdoor water less efficiently as it relates to the water budget. Possession of a pool or a vegetable garden did not have a significant effect on outdoor water use efficiency.

Last, we regressed behavior on the IM variables and environmental contextual factors described above as well as a set of dummy variables controlling for neighborhood of residence. We chose not to present coefficients for neighborhood of residence given that in and of themselves they tell us very little about the characteristics of the neighborhoods in question and are interpreted relative to a base group. However, after controlling IM variables and environmental contextual factors, neighborhood of residence accounts for an additional 9% of the variance in outdoor water use efficiency. The same pattern of results described in the previous model was replicated in the final model. However, the influence of home age on behavior was completely mediated by neighborhood of residence (Baron and Kenney 1986).

Table 3. Summary of effects for models predicting compliance with the water budget

	Core IM Variables		+ Env. Contextual Variables		+Neighborhood of Res.	
Variables	*β*	*SE*	*β*	*SE*	*β*	*SE*
Core IM Variables						
Intention	-.22**	8.39	-.18**	8.06	-.15**	7.91
Perceived Behavioral Control	-.02	4.25	-.03	4.05	-.06	3.95
Attitude	.09	8.81	.06	8.47	.05	8.34
Subjective Norm	.05	7.45	.07	7.10	.09	7.02
Env. Contextual Variables						
Irrigable Area	-	-	-.27***	0.00	-.27***	0.00
Market Value	-	-	.26***	0.00	.19***	0.00
Has Pool	-	-	-.03	9.70	.02	9.64
Home Age	-	-	-.15***	0.37	-.11	0.63
Has Vegetable Garden	-	-	-.07	7.61	-.06	7.56
Irrigated Landscaping Features	-	-	.13**	1.17	.13**	1.17
Has Pond or Fountain	-	-	.11**	10.18	.10**	10.04
Number of Residents	-	-	-.07	2.45	-.05	2.43
Neighborhood of Res.	-	-	-	-	**	**
R^2	.02		0.21		0.28	
ΔR^2	-		0.19		0.07	
N	603		562		561	

*p≤.10, **p≤.05,***p≤.001

Discussion

Attitude – Behavior Relationship

Although we did not utilize an experimental design, and therefore cannot attribute causation, the water budget program appears to have been successful in shaping positive attitudes toward compliance. Mean values for intention to comply exceeded 4.0 on a five point scale. Similarly, mean values for attitudes, subjective normative beliefs, and perceived self-efficacy were all positive toward complying with the behaviors encouraged by the program. As hypothesized, attitude, subjective norm, and perceived behavioral control were all significantly related to an intention to comply with the water budget. These results mirror much of the literature in residential water conservation that has drawn on the IM, the TPB or the TRA (Russell and Fielding 2010: Jorgensen et al. 2012).

However, the observed relationship between intention and behavior - although significant - was quite weak. Although the variance in behavior explained by an intention to comply was small, intention was a significant predictor of behavior controlling for environmental contextual factors and neighborhood of residence. This result suggests that an intention to comply is an important factor driving behavior, but that a variety of other factors are at play in outdoor water use decisions. Several interdisciplinary models of household water use stress the importance of both psychosocial and contextual factors influencing patterns of water consumption (Jorgensen et al. 2009; Syme et al. 2004; Russel and Fielding 2010; Gregory and Di Leo 2003). Our results support the claims made by these authors and extend the literature to consider behaviors encouraged by persuasion and subsequent compliance. Managers must understand these factors in order to remove barriers to acting on the positive attitudes that a persuasive program has been successful in creating.

Perceived behavioral control was not a significant predictor of behavior in our model. In much of the literature on the IM, or TPB, perceived behavioral control explains a relatively large proportion of the variance in behavior and intention (Armitage and Conner 2001). This result may be an artifact of our measurement. Our measure of

PBC may not reflect actual control (Kaiser et al. 2003). Actual control in this instance may be better captured by the environmental contextual factors influencing water use including income, irrigable are of the lawn, and neighborhood of residence among other aspects of the household infrastructure and characteristics of the household. Alternatively, our measure of PBC may have been interpreted by participants to mean that it is their choice to use as much water as they like, rather than a measure of self-efficacy. Perceptions of self-efficacy are an area where information and educational programs can make a substantive difference (Trumbo and O'Keefe 2001; Bandura 1990). Continuing outreach efforts that seek to educate water users on methods to increase efficiency may result in higher levels of perceived self-efficacy in complying with the water budget and ultimately a more efficient use of the resource.

Environmental Contextual Factors

In his 2011 text *Navigating Environmental Attitudes*, Heberlein makes the argument that behavior change initiatives that are based only on cognitive mechanisms like persuasion are unlikely to yield desired outcomes. Behaviors that are difficult, habitual (Gregory and Di Leo 2003), costly, or time intensive are unlikely to change as a result of attitudinal change alone (Kollmus and Agyeman 2002). Instead, he suggests an approach that seeks to manipulate the structure of the context in which behavioral decisions are made in addition to efforts to change attitudes. It is necessary then to understand both the attitudinal and contextual factors that are exerting the greatest influence on behavior (McKenzie-Mohr 2000). In the case of this study, market value (income), water using infrastructure, and neighborhood of residence all had a significant influence on outdoor water use efficiency. Although many aspects of individual water use decisions are outside of the realm of influence of water managers, there are a number of contextual elements that they may be able to manipulate in order to increase outdoor water use efficiency and capitalize on the positive intentions developed by the persuasive program. We discuss them in the sections to follow.

Income and Household Infrastructure

Home value (income) was strongly related to compliance with the water budget. Although the political support may not exist for a general rate increase for water, and the current rate structure in the city generally perceived to be insufficient to influence behavior among affluent water users, there may be sufficient political will to implement a pricing structure that would impact only the very highest and wealthiest consumers. Increasing the financial incentive for conservation would reduce barriers for consumers to act on the positive attitudes that have resulted from the water budget program; potentially increasing the level of compliance.

We observed a significant negative relationship between lot size and compliance with the water budget. These results suggest that individuals with smaller lawns are less likely to comply with the water budget, although they may be using a smaller volume of water overall. We hypothesize that this is a function of the volumetric measure of behavior that we used. Although smaller lots more often exceed the water budget, the volume with which they exceed the budget is generally smaller than larger ones. This suggests that smaller lots are being overwatered to a much greater volume per unit area than are larger ones, but may not in fact be problematic. Further research is warranted to examine this phenomenon before specific recommendations for policy can be made. Given that lot size is often determined by neighborhood in planned communities, there may be an interactive effect between lot size and neighborhood of residence. Future research in this area can elucidate why households with smaller areas of irrigable lawn over water to a greater degree. Although it is speculation we suggest that this could be due to a number of factors including the design of irrigation systems, the area assumed to be irrigated as a function of the water budget, and the resources required to intensively manicure larger lots.

Neighborhood effects on compliance were observed after controlling for household infrastructural characteristics and psychosocial variables. Different residential neighborhoods are governed by different institutions both in terms of formal HOA requirements, and informal in terms of social norms (Turner and Ibes 2011; Schultz et al. 2014). Further research into the specific rules of different HOAs and neighborhood culture, and their influence on water use efficiency is warranted. Developing partnerships with individual HOAs to encourage conservation through institutional change may be a fruitful direction for managers to take (Yakibu et al. 2008). Although changing existing rules may be difficult, information obtained from a study of their effects on water use could inform future development and the formulation of appropriate rules governing the installation of infrastructural features that demand significant amounts of water. Mangers should work with developers in the future to ensure that household infrastructure is designed in a way to reduce water consumption. A variety of technological innovations exist that can help to minimize outdoor water consumption including ET sensors, rainfall shutoff sensors, and rainwater harvesting systems. Given that participants in this study expressed positive attitudes toward conservation, they may be willing to adopt these technologies if the incentives for doing so are sufficient to influence their behavior. Similarly, new residents may be accepting of these technologies if they are mandated in future development.

The informal institutions that influence behavior may also vary between neighborhoods. Although the IM captures elements of perceived social influence on behavior, and the water budget attempts to manipulate those beliefs through social comparison, there are competing normative elements at play. A social expectation to have an aesthetically pleasing landscape, for example, also drives water use (Larson et al., 2009). Determining the influence of these and other social normative expectations on water use and their variation between neighborhoods may aid managers in developing policy that successfully manipulates the context in order to achieve conservation targets.

Limitations

There are a number of limitations to the current study that should be noted. The methods used to calculate the water budget make significant assumptions concerning the composition of a given landscape. Many lawns may not conform to the structure that is assumed. This may confound the accuracy of the behavioral measure. Also, the study was conducted by the water utility presenting a potential for social desirability bias in survey responses (Fisher 1993). However, if this were the case we would not expect to observe a relationship between self-reported attitudes and objectively measured behavior. Replicating this study in a context where there is a stronger normative pressure to conserve may yield a different result. Attitudes may be stronger predictors of water conservation behaviors among residents that have internalized a moral norm to conserve, where there is a greater threat of coercive sanctions for non-compliance, and there is a higher financial incentive to conserve. Last, the study was cross-sectional in nature measuring attitudes and behavior that correspond to one irrigation season. With repeated exposure to persuasive instruments, attitudes and their relationship with water use may change over time. We do not, however, have baseline data on attitudes toward the program when it was first initiated in 2012 to determine to what extent attitudes have changed.

Conclusion

In this study we evaluated consumer attitudes toward water conservation related behaviors encouraged through a persuasive communication, the relationship between those attitudes and compliance, and the environmental factors that facilitate and constrain their adoption. Our results indicate that the program was successful in developing positive attitudes toward compliance and that those attitudes were predictive of behavior. However, managers should now focus their attention on aspects of the environmental context in order to incentive conservation. A variety of mechanisms present themselves including, partnering with HOAs to develop sustainable landscaping requirements that encourage an efficient use of water, pricing mechanisms for the highest water users, and continued education and outreach to improve the knowledge and skills of residential consumers. Demand management initiatives that seek to manipulate the attitudes and behaviors of residential water users must address both the psychological and environmental aspects of behavior within the appropriate context in order to achieve desired outcomes.

CHAPTER III

COMMUNITY ATTACHMENT, CONTEXTUAL FACTORS, AND THE NORM ACTIVATION MODEL: THE CASE OF RESIDENTIAL WATER USE

Residential water use has been characterized as a social dilemma where the benefits of consumption of a common resource accrue to the individual and the costs are born by society (van Vugt 2001; 2002; Schlager 2002). Following the predictions of rational choice, individuals are expected to consume water at a level that fulfills their utility, often with adverse consequences for the broader community (Hardin 1968; van Vugt 1998; Agrawal and Gibson 1999; Schlager 2002). These consequences manifest in the form of reduced water supply (Bithas 2008), degradation of source aquatic ecosystems and groundwater basins (Postel and Richter 2003), and greater potential for the implementation of water use restrictions (Halich and Stevenson 2009) among many others.

However, the predictions of rational choice often do not hold true (Agrawal and Gibson 1999; van Vugt 2001). Previous research has shown that individuals will willingly restrain their use of commonly held resources without coercion (Ostrom 1990; Ostrom 2007; Berk et al. 1980; Shlager 2002). A number of theoretical explanations have been proposed to explain prosocial behaviors like those exemplified by voluntary water conservation. In the social psychology literature, Schwartz's (1977; 1973) Norm Activation Model (NAM) is perhaps the most widely applied (De Groot and Steg 2009). Generally speaking, the NAM hypothesizes that an individual will engage in an altruistic act[1] when they hold a personal norm – or moral obligation - to do so, and that personal norm is activated in the given situation (Schwartz 1977; 1973). Water conservation represents one such act where the benefits of restraint are primarily accrued at the group level and the costs of restraint are born by individual water users (van Vugt 2001;1998; De Groot and Steg 2009; Thøgersen 1996).

The NAM, however, has been criticized by some as being overly individualistic, ignoring the social context in which personal norms are developed and activated (Black et al. 1985). In Schwartz's own words, he states that "individual expectations arise or are learned from shared expectations in social interaction" (1973 p. 353). Internalized moral obligations or personal norms then are a product of an ongoing process of community socialization (Sampson 1988; Kasarda and Janowitz 1974). Given these observations we suggest that one's attachment to community is relevant for understanding the development of internalized personal norms as they relate to prosocial behaviors that influence community resources.

Residential water use, however, is a function of both internal factors like personal norms, and external contextual factors including characteristics of the home, household, and the individuals that reside there (Jorgensen et al. 2009; Syme et al. 2004; Fielding et al. 2012). To understand the effects of attitudinal variables on objectively measured water use these contextual factors must also be accounted for (Fielding et al. 2012). In the present study, we test an extended version of the NAM that incorporates measures of community attachment to better understand the factors that contribute to the development of personal norms to conserve water, the relationship between personal norms and residential outdoor water use, and the influence of socio-demographic and household contextual factors on consumption. We focus on outdoor water use given that it constitutes the vast majority of consumption in single family residential homes in the Western United States and is seen as more elastic than indoor use which is used primarily for cooking, cleaning, and sanitation (Hilaire et al. 2008).

Literature Review

Norm Activation Model and Prosocial Behavior

According to the NAM a Personal Norm (PN) will be activated when an individual is aware that there is a threat posed to an object that they value and that they accept some responsibility for it. These two ideas are referred to as an Awareness of Consequence (AC) and an Ascription of Responsibility (AR), respectively. In turn, PN is a direct antecedent to the performance of prosocial behavior. Personal norms carry a reference to the self. They represent the moral obligations that one holds for carrying out a given behavior (Shwartz 1973). Failure to comply with behaviors congruent with a given PN will result in internal sanctions. It is these internal sanctions that are the mechanism through which PN ultimately influences behavior (Schwartz 1973; Stern 2000).

Thøgersen (1996) argues that environmental issues belong to the moral domain, making the NAM an appropriate tool for the analysis of environmentally significant behaviors. As such, a number of scholars have drawn on the NAM to explain voluntary engagement in prosocial behaviors in the context of natural resource conservation (Harland et al. 2007; Vinning and Ebreo 2002). Vinning and Ebreo (1992), for instance, used the NAM to explain participation in recycling behaviors among residential households. Other studies have explored willingness to pay for environmental protection (Guangano et al. 1994), energy conservation (Zhang et al. 2013; Black et al. 1995), and the burning of yard waste (Van Liere and Dunlap 1978) among many others. Stern et al. (1999) and Stern (2000) extended the NAM to include measures of environmental worldview and personal values antecedent to AR, AC, and PN in the value-belief-norm theory (VBN). A growing body of research has used the VBN in a manner similar to the NAM to explain participation in environmentally significant behaviors (van Riper and Kyle 2014; Raymond et al. 2012; Wynveen et al. 2015).

The common thread among these studies is that they conceptualize voluntary conservation as an altruistic act (Thøgersen 1996). That is, voluntary conservation results in a benefit that is realized by other humans or the ecosystem. Although these studies, and others, have furthered our understanding of the utility of the NAM for explaining prosocial (pro-environmental) behavior, they often fail to acknowledge the social context in which they occur. By definition, altruism necessitates the presence of a human or non-human other that is influenced by a given action. The voluntary restraint of residential water use has implications for other members of one's community. In addition to AC ones' attachment to the community may have implications for the activation of a PN to conserve community resources. Research in community sociology provides insight on human social life and the development of affective bonds between individuals and their community that can shed light on this relationship.

Community Attachment and Prosocial Attitudes and Behaviors

"Community" is a construct that has been defined in a number of ways, in large part, owing to its relevance to a number of social science disciplines. It is evidenced in the social fields that constitute the social interactions and bonds individuals share with other human beings in addition to the territories in which these fields exist (Kaufman 1959; Kasarda and Janowitz 1974; Theodori 2000; Theodori and Kyle 2013). Reflecting the so-called "systemic model" of community, Kasarda and Janowitz (1974) state that it is a "social construction with its own lifecycle, possessing ecological, institutional, and normative dimensions" (quoted in McCool and Martin 1994, p. 30). Theodori (2005, pp. 662-663) describes community as "a place-oriented process of interrelated actions through which members of a local population express a shared sense of identity while engaging in the common concerns of life". These definitions share two common themes; 1) that community is socially constructed, reflecting the social world and geographic context relevant to the individual, and 2) community carries normative proscriptions that guide individual behavior in the pursuit of common interests. We adopt this conceptualization of community drawn from community sociology.

Community attachment - as alluded to earlier - is defined as the "extent and pattern of social participation and integration into the community, and sentiment or affect toward the community" (McCool and Martin 1994). It is one of many concepts of interest for understanding community social dynamics and socially relevant attitudes and behaviors like prosocial PN (Trentleman 2009; Sampson 1988). Past work in the community sociology literature that has concerned community attachment has developed along two distinct lineages. The first has examined community attachment as an outcome. That is, scholars have sought to determine the social, ecological, and individual attributes that account for variation in the affective bonds between individuals and their social group and their patterns of social interaction (Mattairtta-Casacante et al. 2010; Beckley 2003; Brehm 2007; Brehm et al. 2004; 2006)

In the second line of research, which is of primary relevance for our investigation, a limited number of studies have examined the utility of community attachment as a predictor of attitudes toward community resource development, environmental concern, and participation in prosocial behaviors. For instance, McCool and Martin (1994) examined the relationship between community attachment and perceptions of tourism impacts in a rural Montana community. In their analysis, they found that community attachment was related to negative evaluations of tourism impacts on community resources. Takashi and Selfa (2014) found that community attachment, environmental attitudes, and community satisfaction, were all associated with the adoption of behaviors intended to curb the individual consumption of natural resources. Theodori (2004) examined the relationship between community attachment and community satisfaction, on engagement in collective action behaviors intended to solve community problems. He found support for the notion that community attachment, but not community satisfaction, is an important predictor of collective action behaviors at the community scale. Last, Kyle et al. (2010) tested the relationship between community attachment and participation in community based activities to mitigate the risks of wildland fire. In their work they found community attachment to be a significant predictor of both self-reported community action behaviors and future intentions to engage in community level mitigation activities. Collectively, these studies suggest that the more strongly one is attached to their community the more likely they are to: a) be sensitive to the individual impacts their behavior has on community resources, b) hold prosocial attitudes, and c) provide for the provision of community resources through specific behaviors. We hypothesize that community attachment is an antecedent to the development of a PN to conserve water as individual water use has implications for the broader community (van Vugt, 2001).

Contextual Factors and Outdoor Water Use

To understand the effect of attitudinal variables on outdoor water use, aspects of the context in which water use decisions are made must also be accounted for. Past work has shown that a variety of socio-demographic and infrastructural characteristics of individuals and the household are highly relevant in understanding outdoor water consumption (Jorgensen et al. 2009; Fielding et al. 2012). Income, for instance, has been revealed to be one of the most consistent and significant predictors of household water use across the literature (Corral-Verdugo et al. 2003; Tinker et al. 2005). As Harlan et al. (2009, p. 692) state "*ceteris paribus* higher income households use more water" (Hanak and Brown 2006: Corral-Verdugo et al. 2003; Vickers 2001). In addition to income, age has also been found to be related to household water use (Gregory and Di Leo 2003). Older residents have different demands for outdoor water than younger ones reflecting different positions in life (Fielding et al. 2012). However, the effects of age on water use are not necessarily linear, but rather correspond to variation in demands that are related to children living in the home and other aspects of the household lifecycle related to age (Fielding et al. 2012). As one might expect, research has shown that the number of residents in a home is related to household water use; with a higher number of residents yielding greater consumption (Jeffrey and Geary 2006; Jorgensen et al. 2014).

Similarly, characteristics of the household infrastructure are also related to outdoor water consumption (Fielding et al. 2012). Syme et al. (2004) found that the size of a household's lawn, possession of a swimming pool, and lawn characteristics (highly manicured etc.) were related to household outdoor water use. Harlan et al. (2009) found that characteristics of the household infrastructure including the possession of a swimming pool and size of the lawn influenced outdoor consumption. Consequently, we hypothesized that in addition to attitudinal variables captured by the NAM, outdoor water use is also influenced by the socio-demographic characteristics of individuals and the composition of the water using infrastructure that they possess.

Hypothesized Model

As reviewed above, research in the community attachment literature illustrates that an individual's attachment to community shapes the attitudes and behaviors that they display towards it (Takahashi and Selfa 2015; Brehm et al. 2006; Theodori 2004). We hypothesize, then, that the affective meanings that one ascribes to their community also shapes their personal normative beliefs related to the use of community resources. The more strongly one is attached to their community, the more likely they are to have internalized a PN to use community resources in a manner that does not impose harm on other members of the community – the object of community attachment. Following the NAM we hypothesize that AC is a positive predictor of PN, and that PN, CA, and AC are negatively related to objectively measured outdoor water use after accounting for relevant socio-demographic and household infrastructural factors that influence demand. These hypotheses are summarized graphically in Figure 3.

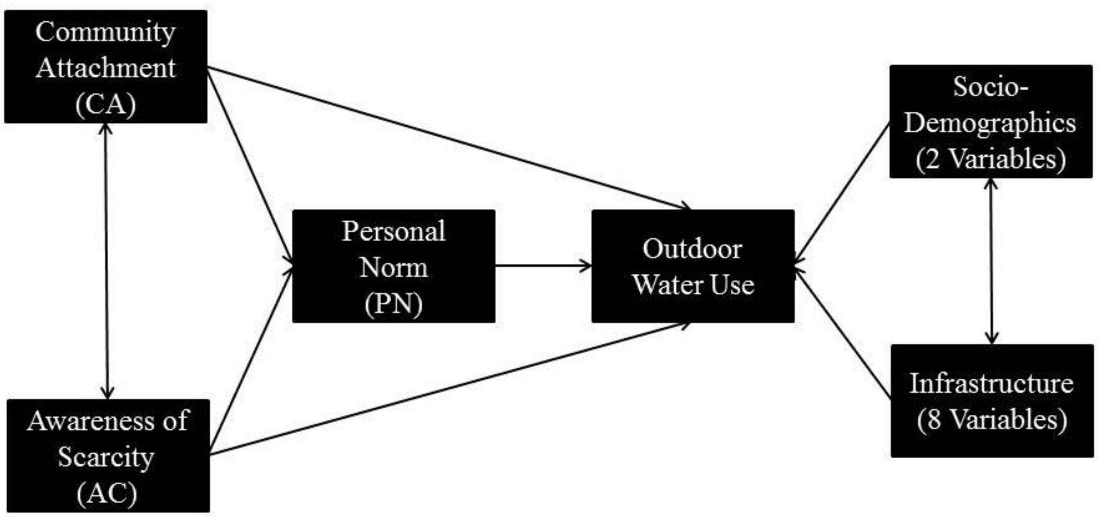

Figure 3. Hypothesized model predicting residential outdoor water use.

Method

Study Context

In order to test these assertions, we developed and administered a questionnaire in collaboration with the City of College Station Utilities Water Services Department. College Station is a rapidly growing urban-suburban community located in east central Texas. The U.S. Census (2013) estimates there are roughly 100,000 residents in the city. Under a moderate growth scenario it is projected that by 2025 the city could experience as much as a 50% increase in population (City of College Station 2010). As a result of these projections it is expected that there will be an unmet water need of around 6,000 acre feet by the year 2060 (TWDB 2012). Conservation is one of the main mechanisms that the city has identified to meet these concerns. Therefore, understanding the factors that shape water users conservation attitudes and behaviors is important for the development of residential demand management policy.

Data Collection

Study participants consisted of 2,500 randomly selected single family detached homes. Households were identified for participation in the study if they resided in a neighborhood that had average outdoor water consumption greater than 100,000 gallons during the period 2008 to 2011 (n=5,565 households). These households represent the most managerially relevant group to target for conservation given that they are the largest water users in the city. Questionnaires were administered through the mail following a modified version of the Dillman tailored design method (2014). Four points of contact were established: 1st) A letter describing the purpose of the study; 2nd) One week following the mailing of the letter survey packets containing a cover letter, survey questionnaire, and prepaid return postage were sent to participants; 3rd) One week after the mailing of the initial survey packet a follow up reminder/thank you postcard was sent to non-respondents; and 4th) One week after the mailing of the postcards a second survey packet with cover letter, questionnaire, and pre-paid return envelope was sent to non-respondents. Data collection took place during the period May to August 2014. Collection efforts yielded 654 usable surveys for an effective response rate of 26%. Checks for non-response bias yielded no significant differences in household characteristics (lot size, home value, age of home) or water use between survey respondents and non-respondents, leading us to conclude that the sample is representative of the larger population of single family detached households in the city from which the sample was drawn.

Measures

We operationalized community attachment using two items adapted from the literature (Theodori 2004; Kyle et al. 2010). Respondents indicated their agreement with the statements “Overall, I am attached to my community” and “I am concerned about the future success of my community”. PN was assessed with three items “I feel obligated to reduce my water use”, “Using less water is the right thing to do” and “I would feel guilty if I didn’t do my part to reduce my water use” adapted from Harland et al. (1999) and Steg and De Groot (2010). AC was assessed with two items “My community has plenty of water for the future" - reverse coded - and "Water supply is a serious problem for my community". All items were measured on a five point likert scale where 1 = strongly disagree and 5 = strongly agree.

Socio-demographic characteristics were operationalized using two measures; income and age. Market value of the home was drawn from county tax assessment records and used as proxy for household income following Tinker et al. (1995). Respondent age was drawn from survey results. Household infrastructural characteristics were operationalized with seven measures drawn from a combination of survey results and county property tax assessment records. "Irrigable area" is the area of the lawn subject to irrigation (sqft). Irrigable area was assumed to be the size of the parcel minus the footprint of the home/outbuildings and driveway calculated from GIS data obtained from the city of College Station. "Irrigated landscaping features" were the number of irrigated flower beds etc. other than the lawn subject to irrigation. "Home age" is the age of the home in years. "Age" is the respondent's age in years. "Number of residents" is the number of full time residents in the household. "Has garden", "Has pool" and "Has pond or fountain" were all dichotomous items indicating whether or not that household has that water using infrastructural element.

Monthly water use records were obtained for each household for the period January 2014 to December 2014 from the city of College Station Water Services Department. Average monthly winter consumption (January and February) was used as a proxy for indoor use given that little to no irrigation occurs during these months following Syme et al. (2004). Average monthly winter use was subtracted for each monthly water use observation for the period April through October and summed to obtain a total irrigation season outdoor water use. Records for survey responses, county property tax assessment records, and monthly water use were merged for each household in the sample.

Table 4. Descriptive statistics for NAM attitudinal variables, community attachment, water use, and contextual factors

Variable	*M*	*SD*	Min.	Max.
Total Outdoor Water Use (Thousand. Gallons)	70.42	56.02	0	379.14
Socio-Demographics				
Market Value ($)	245,125	106,484	99,580	1,043,990
Age (yrs)	58.39	16.13	21	96
Infrastructure				
Irrigable Area (sqft)	13138.19	6944.46	4751.00	86248.00
Home Age (yrs)	18.45	10.20	4	51
Irrigated Landscaping Features	2.95	2.97	0	30
Number of Household Residents	2.70	1.32	0	8
Pool	0.11	0.31	0	1
Vegetable Garden	0.23	0.42	0	1
Pond or Fountain	0.11	0.31	0	1
Community Attachment (CA)	4.28	0.69	1	5
Overall, I am attached to my community	4.13	0.28	1	5
The future success of my community is very important to me	4.43	0.71	1	5
Personal Water Conservation Norm (PN)	3.77	0.74	1	5
I am obligated to do my part to reduce my water use	3.81	0.81	1	5
Using less water is the right thing to do	4.02	0.77	1	5
I would feel guilty if I didn't do my part to reduce my water use	3.46	0.98	1	5
Awareness of Scarcity (AC)	3.18	0.84	1	5
My community has plenty of water for the future (r)	3.30	0.96	1	5
Water scarcity is a serious problem in my community	3.06	0.97	1	5

Descriptive statistics for the measures are presented in Table 4. The demographic profile of respondents is not reflective of residents of the city as a whole, but consistent with the highest water using households. On average study participants were 58.1 years old and predominantly male (62%). Participants were highly educated with greater than 50% completing a Master's degree. On average respondents have resided in their current homes for 11.1 years.

Analysis and Results

We tested our hypotheses using structural equation modeling techniques in two steps following the recommendations of Anderson and Gerbing (1988). All analyses were conducted using the full information maximum likelihood (FIML) estimator in order to account for missing values (Enders, 2001). First we tested a measurement model for the constructs AC, PN, and CA using confirmatory factor analysis in STATA version 14, allowing the three latent variables to freely co-vary. Fully standardized factor loadings, standard errors, and measures of internal consistency are summarized in Table 5. Following the recommendations of Hu and Bentler (1999) - RMSEA<0.06; CFI, NNFI>0.95 - we found the data to be an adequate fit for the hypothesized measurement model (χ^2 = 22.38, df = 11, p=0.02; RMSEA = 0.04; CFI = 0.99; NNFI = 0.98). All fully standardized factor loadings were above the minimum of 0.7 suggested by Fornell & Larcker (1981). The internal consistency for the scales measuring the three constructs were, for the most part, adequate following the recommendations (Cronbach's alpha ≥0.7) of Nunnally and Bernstein (1994); Cronbach's alpha ranged from a low of 0.66 to a high of 0.83. Following these results we created item parcels containing the mean of all items in each construct (Little et al. 2002).

Table 5. Results for test of the measurement model

Items and Constructs	*λ*	*SE*	*z*-value
Community Attachment (CA) α =.73			
Overall, I am attached to my community	.74	.05	15.44***
The future success of my community means a lot to me	.78	.06	13.41***
Awareness of Scarcity (AC) α =.66			
My community has plenty of water for the future (r)	.70	.07	10.81***
Water scarcity is a serious problem in my community	.71	.07	11.80***
Personal Water Conservation Norm (PN) α =.83			
I am obligated to do my part to reduce my water use	.89	.02	49.10***
Using less water is the right thing to do	.76	.02	34.70***
I would feel guilty if I didn't do my part to reduce my water use	.76	.02	34.31***

p≤0.10=*, p≤.05=**, p≤.001=***; (r) = reverse coded item

Next we used path analysis to test the hypothesized structural relationships in our model. Personal norms were regressed onto the manifest indicators CA and AC, and outdoor water use onto PN, AC, CA, socio-demographics, and infrastructural factors. All exogenous variables were allowed to co-vary. Again, we found that the data were an adequate fit for the hypothesized model (χ^2 = 19.17, df = 9, p=0.02; RMSEA = 0.02; CFI = 0.97; NNFI = 0.91). Both CA (γ =0.19, p<0.01) and AC (γ = 0.29, p<0.01) were significant positive predictors of PN. Confirming our hypothesized relationships where PN is positively influenced by both AC and CA. Together CA and AC explained 12% of the variance in PN. Personal norms (β =-0.09, p<0.05) and contextual factors accounted for 29% of the variance in outdoor water use. AC and CA did not have a direct effect on outdoor water use. However, indirect effects between CA (β = -0.01, $p<0.05$) and AC (β = -0.02, $p<0.05$) and outdoor water use were observed. Irrigable area, market value, irrigated landscaping features, home age, and respondent age were all significant predictors of outdoor water use. We did not find a significant effect for possession of a pool, vegetable garden, or pond/fountain on outdoor water use. A summary of model results is presented in Table 6.

Table 6. Summary of effects for path model predicting PN and outdoor water use.

DV←	IV	Coefficient	*SE*	R^2
Direct Effects				
PN	AC	0.29***	0.04	0.12
	CA	0.19***	0.04	
Outdoor Water Use	PN	-0.09**	0.04	0.29
	AC	0.06	0.04	
	CA	0.03	0.04	
	Market Value	0.28***	0.05	
	Age	0.18***	0.04	
	Irrigated Landscaping Features	0.13**	0.04	
	Irrigable Area	0.17**	0.04	
	Number of Residents	0.08*	0.04	
	Has Pool	0.00	0.04	
	Has Vegetable Garden	-0.04	0.04	
	Has Pond or Fountain	0.05	0.04	
	Home Age	-0.09**	0.04	
Indirect Effects				
Outdoor Water Use	AC	-0.02**	0.01	
	CA	-0.01**	0.01	

p≤0.10=*, p≤.05=**, p≤.001=***

Discussion

Our results support the premise on which this investigation was based; that the greater the extent to which an individual is attached to their community, the more likely they are to internalize a moral obligation to conserve a community resource, and that PN to conserve water results in reduced water consumption. Although previous work drawing on the NAM has been quite successful in explaining the internal processes that result in the activation of personal norms for environmental conservation, relatively less attention has been given to the affective meanings that one ascribes to the social context in which resource use decisions occur. Our results suggest that further research is warranted in the area to determine the impact of social participation and affective bonds with community in the development of personal norms that result in prosocial behaviors like residential water conservation. Previous research has demonstrated that community attachments are predictors of prosocial attitudes and behaviors (Takahashi and Selfa 2015; Brehm et al. 2006; Theodori 2004). However, this is the first study, to our knowledge, to examine the relationships between community attachment and personal norms related to the conservation of community resources. As Baldassari and Grossman (2013, pp. 2) state "…prosocial behavior toward a person classified as an in-group member does not (necessarily) stem from their proximity; rather it is (at least partially) derived from the ego's level of *attachment* to his or her shared group." – emphasis in original. Our findings provide evidence in support of this idea.

Although socio-demographic and household infrastructural characteristics account for a greater proportion of the variance in water use than PN, AC, and CA these factors are largely outside the realm of influence of water managers. Attitudes, however, can be influenced through persuasion, normative feedback, and a variety of other social marketing techniques (McKenzie-Mohr 2000). Recognizing this limitation, van Vugt (2002) suggests an alternative model of resource conservation that stresses the importance of community. In fact, he states (pp. 791) that “in situations where community members have developed a strong attachment to their community, resources can be managed successfully via the self-regulating activities of community members”. We suggest that the internalization of a personal conservation norm is one mechanism through which self-regulation occurs. Our results demonstrate that those who hold a greater PN to conserve community resources do in fact use less outdoor water than those with a lower PN. Additionally, CA and AC have a negative indirect effect on outdoor water use.

The applied implications stemming from this work, therefore, point toward the role of community in the development of prosocial normative beliefs. Community development is an opportunity to create resilience to resource shortages and mitigate the potential impacts of market forces on water supply. The broader community development literature offers several insights on how to enhance community participation, integration, and potentially the affective bonds between individuals and the community. Theodori (2008) defines community development as “a process of building, strengthening, and maintaining the notion of community”. Doing so requires removing barriers to community interaction and participation in community action (Theodori 2008). Community attachment is strongly related to length of residency (Theodori 2004;

Kasarda and Janowitz 1974), one's position in the social structure (Theodori 2004), and the psychical characteristics of the setting (Brehm 2007; Mataritta-Cascante et al. 2010). Exploring these concepts within the context of our study may provide insight on the mechanisms that drive community participation and attachment, and ultimately engagement in resource conservation.

Our model hypothesizes that two factors are relevant in the development of personal conservation norms 1) a perception of scarcity, and 2) an attachment to community. The model that we tested accounted for 11% of the variance in PN, leaving a significant portion of the variance unaccounted. Future research should seek to determine additional factors that might explain a moral obligation to conserve community resources. We also did not have measures for AR in this study. Inclusion of AR may account for a greater degree of the variance in PN, and have additional indirect effects on water use. Also, in communities where water scarcity presents a more acute threat, PN may be activated to a greater degree. Repeating this study in a community where water scarcity has historically been more salient may find a stronger relationship between PN and water use.

Relatively few social psychological studies of natural resource conservation have drawn on objective behavioral measures. The vast majority of studies in the water conservation literature, for instance, have relied on behavioral self-reports and intentions as outcome measures (Jorgensen et al. 2009). Our results add to a limited number of studies that have shown significant effects of attitudinal variables on objectively measured water use. More work is needed in this area to determine the boundary conditions under which attitude based theories can account for water use behavior, and what additional variables might be omitted by the original formulation of theories like the NAM. Following Black et al.'s (1985) research on energy conservation, and models proposed by Jorgensen et al. (2009) and Fielding and Russell (2011) we included socio-demographic and infrastructural variables in our model of water use. Our results support the assertion that researchers must account for these variables when attempting to model household water use and understand the social psychological phenomena that drive resource use decisions.

There are a number of limitations to the current study that should be noted. The results presented here are from a cross sectional study which limits the causal inference (Rindfleisch et al. 2008). However, our hypotheses were derived from theory (Schwartz 1977; 1973), and hypothesized relationships determined a priori. Although we cannot necessarily interpret our results as evidence of causality our data proved to be an acceptable fit for the hypothesized model. Additionally, there are other factors that influence water use that are not taken into account as a function of the study design. Our measure of water use is aggregated to the irrigation season. Water use likely varies throughout this period as a function of climate and other time varying factors (Balling and Gober 2007). This is likely reflected in the relatively low explanatory power of the model ($R^2 = 0.29$) in accounting for household outdoor water use.

Better understanding the factors that lead to the internalization of moral obligations to use community resources responsibly will aid managers in meeting rising demands for water. Climate change and population growth both present sources of uncertainty for managers planning for future water supply. A responsive populace that embraces the needs of the community in meeting these challenges will aid managers in achieving conservation goals for water supply in the future.

CHAPTER IV

EVALUATING THE EFFICACY OF AN INFORMATION-BASED RESIDENTIAL DEMAND MANAGEMENT PROGRAM

Programs that encourage conservation through the provision of education, information, and persuasion are some of the most commonly used policy instruments in the residential water sector (Syme et al. 2000; Michelsen et al. 1999). In many cases these instruments are the only ones available to water managers as the political climate precludes the use of pecuniary strategies or market-based instruments to manage residential demand (Morehouse 2000). However, the efficacy of information-based conservation programs in bringing about a change in water use remains poorly understood (Seyranian et al. 2015; Syme et al. 2000; Michelson et al. 1999). Some scholars maintain that in the long-term "…conservation needs will always lack salience or immediacy for consumers, and consequently, voluntary conservation is impossible to motivate" (Syme et al. 2000). Others contend that feedback information and persuasive messages that employ specific behavioral principles can have an immediate impact on water use –at least in the short term (Schultz 2014; Seryaninan et al. 2015; Berk et al. 1980). Relatively little research has been directed toward understanding the impacts of persuasion, education, and feedback information programs on water use over longer periods of time while drawing on individual level household data in the field (Bernedo et al. 2014; Ferraro and Miranda 2013; Ferraro et al. 2011; Schultz et al. 2009; 2014). Obtaining reliable data and drawing causal inferences from counterfactual changes in water consumption as a function of information-based programs can be problematic (Syme et al. 2000). However, developing a better understanding of the ability of these programs to bring about a change in water use behavior, and sustain that change over time, is critical if utilities are to meet rising demands for increasingly scarce and contested freshwater supplies. In the present research we evaluate the efficacy of one such information-based conservation program in affecting a change in water use among residential water customers over a period of three years.

The Current Research

Water managers in College Station, Texas, have engaged in an ambitious campaign to improve the efficiency of outdoor water use among a subset of the city's most prolific water customers. Households residing in the top water using neighborhoods represent roughly 15% of the total water accounts in the service area, yet are responsible for as much as 40% of the city's water consumption. Consequently, these households have received a significant amount of attention in an effort to reduce their water use. Consistent with much of the Western United States, the vast majority of consumption for these households is done outdoors for lawn and landscaping irrigation (Thompson 1999). As a part of the conservation program these households have been provided with annual feedback information on their outdoor water use along with a comparison of that water use to an "efficient" standard, and to the average outdoor water use of their neighborhood at the beginning of the major outdoor water use season running from April to October. Collectively, this information has been referred to as a "water budget". It is intended that by providing customers with the water budget messages it will motivate them to bring their water use in-line with what is considered appropriate in terms of efficiency as defined by the utility, and what is normal in terms of the behavior of their peers. In the present research we set out to answer three specific questions related to the program: 1) has there been a reduction in water use in our study population as a function of the messages? 2) if there has been a reduction in water use, how has this reduction persisted over time? and 3) does the effect of the messages vary among recipients as a function of their water use during the period before the messages were administered? Evaluating the efficacy of the program as whole will add to a growing body of literature in information-based residential water conservation program evaluation and establish a baseline against which to judge future management actions. Additionally, determining variability in consumer responses to information-based instruments can aid policy makers in directing scarce conservation resources toward the most responsive consumers to effect the greatest change in consumption possible (Ferraro and Miranda 2013). In the section to follow we review past work that has used feedback information in the context of residential water conservation.

Literature Review

Feedback refers to providing consumers with information about their past or current behavior with the intent to influence their behavior in the future (Abrahamse et al. 2005). In the residential water literature many studies have examined the impacts of feedback information on subsequent water use. These studies have taken on two dominant forms.

The first has focused on providing near real-time information on water use through so-called “smart meters”. Smart meter studies are predicated on the assumption that the more salient water consumption information can be made, the more users will be motivated to conserve (Boyle et al. 2013). Results from this largely a-theoretical literature are mixed at best as research has shown that descriptive information is not necessarily incorporated into the decisions of consumers and associated gains in conservation with these interventions are relatively ephemeral (Schultz 2002).

The second is rooted in social comparison. Normative approaches to behavior change like the Focus Theory of Normative Conduct (Cialdini et al. 1990) and Community Based Social Marketing (McKenzie-Mohr 2000) have gained increasing attention as management tools in natural resource conservation (Abrahamse et al. 2005). Drawing on Festinger’s (1954) social comparison theory this approach is based on the notion that individuals behave in a way that is consistent with the behavior of their peers (Ferraro et al. 2011). Research has consistently shown that when individuals are given information that describes their behavior in relation to the behavior of their peers, or the expectations of their peers, aligned with a message concerning the appropriateness of that behavior, they will adjust their behavior to be more closely in-line with that of the social group (Cialdini et al. 1990; 1991; 2006). Critics of the so-called information-deficit model characterized by many smart meter studies see the normative benchmark provided through social comparison as a critical mechanism for behavior change that is rooted in theory absent from more descriptive approaches (Schultz 2002). That is, information alone is not sufficient to achieve a change individual behavior; information must be presented in a way that activates specific internal motivational processes and aligned with a statement concerning its appropriateness (Schultz et al. 2007; Cialdini et al. 1990).

Using the social comparison framework, Schultz et al. (2009) found that the administration of normative messages that compared individual and neighborhood water use yielded a significant reduction in consumption during a period of drought above and beyond technical advice or appeals for conservation when the message was aligned with a statement that approved or disapproved of their level of consumption. These results were replicated in a later study (Schultz et al. 2014) and extended to show that the extent to which individuals feel a moral obligation to conserve moderates the impact of social influence on behavior change. Further, Ferraro et al. (2009; 2011), in one of only a few long-term investigation of the impacts of social norms interventions on residential water use, were able to show that a single message resulted in a policy relevant level of behavior change six years after it was administered. However, the strength of the treatment effect declined over time. Feedback experiments rooted in social comparison have been implemented in a number of other contexts as well (Cialdini et al. 2006; Goldstein et al. 2006). For instance, similar studies in the energy sector have shown that norms-based messages can affect residential consumption (Ayres et al. 2009; Alcott, 2012; Costa and Kahn, 2013; Shultz et al. 2007). Alcott and Rodgers (2012) summarize the results of a number of large scale field experiments in energy conservation finding support for the utility of norms-based messages in applied resource conservation.

Social influence, however, can emanate from a variety of different social relationships (Fishbein and Ajzen 2010). French and Raven (1959) hypothesize that social influence is a function of the perceived power of social agents – i.e. water managers, neighbors etc. - to administer rewards and coercive punishments; legitimate power of social agents over the individual as a function of social and political structure; the social agent possessing expertise; and an individual's underlying desire to comply with the group with which one identifies. Therefore, comparing individual to group behavior is not the only mechanism that can be used to influence residential resource use. Each of these sources of power can potentially influence behavior, and be manipulated for the purpose of behavior change through normative feedback (Fishbein and Ajzen 2010). The water budget messages, which are the focus of the current research, contain two types of normative comparisons that reflect the sources of power and social influence hypothesized by French and Raven (1959). The first is based on social comparison where individual water use is compared to neighborhood water use in the manner described above and presented to individual households. The second is based on efficiency and the expectations of the governing institution. By telling water customers how much water they "should" be using, and comparing individual water use to that standard, the utility is imposing a normative prescription on the behavior of the consumer. The water utility possesses expert and legitimate power concerning the administration of the public water supply. Therefore, the water budget, considered the normative prescription of the governing institution, has the potential to influence individual behavior and motivate compliance. Although we cannot discern the relative influence of these two normative comparisons since they were administered simultaneously, we can determine whether the combined effects of the messages have had a significant impact on residential water use among our study participants.

To answer our research questions we use a quasi-experimental design that draws on monthly household water meter readings and detailed information regarding the administration of the water budget messages across the broader community over the period 2008 to 2014. Our study differs from previous work in this area in a number of ways. First, the majority of past research in voluntary water conservation and feedback experiments has documented short-term contemporaneous changes in water use behavior during periods of acute water scarcity. These studies have typically administered a single persuasive message, over a single season, to a relatively small population (Bernedo et al. 2014). In this study we examine water use in a relatively large population (n=5,565) over a treatment period of three years (2012, 2013, and 2014) subject to annual repetition of messages and a baseline period before they were administered (2008-2011). To our knowledge the only other similar study in the water sector using norms-based feedback information conducted in the field at this scale was done by Ferraro et al. (2009; 2011; 2014; Bernedo et al. 2014; Ferraro and Miranda 2013). Second, until more recently, many studies examining water use and voluntary conservation have focused on general mass media messages (Michelsen et al. 1999). In the present study, messages were tailored to water users and contained feedback information on outdoor water use in addition to appeals for conservation, normative comparisons, and information on how to save water – an approach that has shown to be successful in both the laboratory and the field (Schultz et al. 2009; 2014; Ferraro et al. 2011). Last, many of the previous studies that have attempted to quantify the impacts of voluntary water conservation campaigns have used the municipality or utility as the unit of observation cataloguing subsequent changes in aggregate water use over time (Berk et al. 1980; Agras et al. 1980). We draw on individual household water meter readings as our unit of observation. In the section to follow we provide a detailed overview of the study context and methods employed to test our research questions, and discuss our results in the context of residential demand management.

Method

Study Context

The city of College Station is located in East Central Texas. U.S. Census estimates from 2013 indicate that the city is home to just over 100,000 residents. Growth projections, however, anticipate significant increases in the resident population over the next 20-30 years (City of College Station 2012). Water supply for the utility comes almost exclusively from the Carizo-Wilcox aquifer. Although the utility has the secure water rights needed to increase the capacity of the system to pump, store, and distribute water, conservation has been identified as the preferred alternative. If nothing is done to curb demand or increase supply it is expected that by 2060 the utility will have an unmet water need of roughly 5,600 acre-ft per year (TWDB 2012). The water budget program was initiated with these concerns in mind.

Selection of Message Recipients

Households were identified to begin receiving the water budget messages in 2012 if they resided in a neighborhood that had an annual April through October average household water consumption greater than 100,000 gallons over the period 2008 to 2011. April through October water use was targeted given that the majority of outdoor water use occurs during this period. All households residing in these neighborhoods received the messages regardless of whether or not their individual usage met this criterion. Consequently, there is quite a bit of variability in water use within the study population. All messages were sent through the mail to postal addresses at the beginning of the irrigation season. In total 14 neighborhoods received feedback information through the program.

The Water Budget Messages

As mentioned previously the water budget communications contain two types of feedback, information and comparison. Household outdoor water use was compared to the water budget determined from a water balance for lawn water requirements at the monthly time step following the equation:

$$WB\ (\text{gal})_{\text{month}} = \text{Irrigable Area}\ (\text{ft}^2) * [(K_c * PET\ (\text{in}) - P\ (\text{in}))] * .6\ (\text{gal/ft}^2)$$

WB is the monthly water budget in gallons, Irrigable Area is the area of the household's lawn subject to irrigation, K_c is a crop coefficient assumed to be St. Augustine grass uniformly, PET is the monthly total potential evapotranspiration in inches, P is precipitation in inches, and .6 is a conversion factor. The water budget represents the maximum amount of water a household should be using in order to keep their lawn in a healthy condition. Water use in excess of this amount is considered an inefficient application of irrigation water and consumers are encouraged to comply with the recommendation. Consumers are under no obligation to comply and the information is meant to motivate the efficient use of water and conserve supply. The water budget was calculated for each month in the previous irrigation season and presented to participants at the beginning of the next. For example, households in 2014 would receive feedback on their irrigation season water use in 2013 compared to the water budget. An example water budget graph is presented in Figure 4. In months where precipitation exceeds evapotranspiration the water budget is set to zero. In these months no irrigation water was needed to keep their lawn alive, heathy, and green.

In addition to the efficiency comparison, households received a comparison of their outdoor water use per square foot of lawn to that of their neighborhood average. Outdoor water use was calculated by subtracting average January – February monthly water use for each month during the irrigation season. Since the lawn vegetation is dormant during the winter months, winter water use makes a good approximation of indoor consumption (Syme et al. 2004). Households that had dedicated outdoor irrigation water meters were excluded from analysis (n~80). In months where subtracting indoor water use resulted in a negative value outdoor water use was set to zero. Irrigable lawn area was calculated using GIS files for parcel size and building footprints, assumed to be the area of the parcel less the total area of hard surfaces – i.e. driveways - and buildings.

Along with the two normative comparisons, households received information on how to reduce consumption and an injunctive message about their consumption that read "Under-Budget or Below-Average Water Use: If your charts show that you are under-budget or below average for your neighborhood – keep up the good work!" "Over-Budget or Above-Average Water Use: You may be able to realize substantial savings on your water bill by using conservation practices such as covering a swimming pool, fixing irrigation leaks or adjusting your irrigation controller."

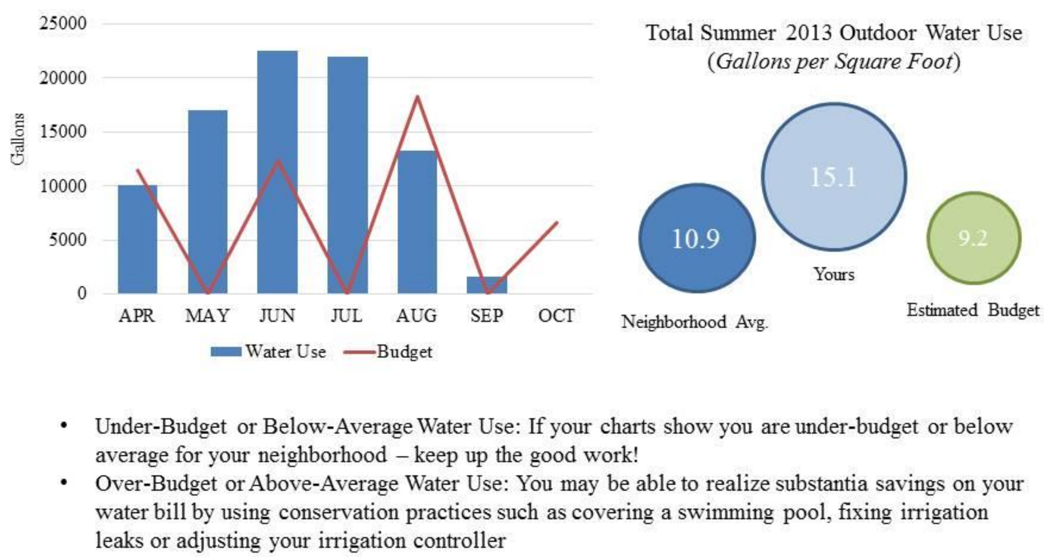

Figure 4. Example Water Budget

Analytical Approach

We used a difference-in-difference fixed-effects panel data model to test for the impacts of the water budget messages on monthly irrigation season household water use (for a detailed treatment of the difference-in-difference design see Wooldridge 2009). Although our design is not truly experimental, the effect of the messages on water use can be interpreted relative to a control group that did not receive the messages in the periods before and after they were administered. In order to do this we developed a pseudo-control group for comparison. Households that received the water budget communications are all single family detached homes. Therefore, we limited households included in the pseudo-control to single family detached homes that fell within the same bounds of the treatment group in terms of age of the home, lot size, market value, and living area. Household characteristics were obtained from publicly available county tax assessment records (BCAD 2013). One main assumption of the difference-in-difference model is that the control group and the treatment group are on so-called "parallel paths". That is, if it were not for the effect of the treatment one would expect the two groups to respond to environmental stimulus similarly over time. Limiting the groups to the same range of exogenous characteristics maximizes the odds of the assumption being met (Wooldridge 2009).

The fixed-effects model is well suited for program evaluation given that it can provide an unbiased estimate of the treatment effect while requiring minimal knowledge of the individual units of observation (Wooldridge 2009; Wooldridge 2011). In this case knowledge of time invariant household characteristics (e.g. lot size, number of household residents, etc.), although relevant to understanding demand moreover, are not needed to test for the effects of the informational treatment on water use. In the fixed-effects model time invariant variables are essentially averaged out (Wooldridge 2009). Our analysis is limited to the months April through October given that the water budget program targeted only outdoor water use, feedback was provided for this period of time, and this is the period during which the vast majority of outdoor water use occurs.

Measures

Household water use "$water\_use_{i,t}$" was taken from monthly water meter readings obtained from the city of College Station Utilities Water Services Department. Average irrigation season (April to October) household water use ranged from a low of 70,650 gallons for the pseudo-control group in 2014 to a high of 165,890 gallons for the treatment group in 2011. Only households that had complete water use records for the entire period of analysis were retained leaving a total of 8,816 households with 740,544 water use observations. Our treatment group consisted of 4,255 households and our pseudo-control consisted of 4,561 households.

Given that water use varies temporally with climatic conditions both within the irrigation season and between them we included monthly measures of precipitation and monthly average maximum daily air temperature in our models. "$precip\_total_t$" is the total monthly precipitation in a given month in inches; and "$ave\_maxtemp_t$" is the average daily maximum air temperature in a given month in degrees Fahrenheit. Climate measurements were taken from a combination of three weather stations located around

College Station, TX. For the period April 2008 – October 2013 weather data were obtained from the Texas A&M extension service weather station on the Texas A&M golf course. For the period April 2014 – October 2014 this station was moved to the Texas A&M turf experiment station and data for that period taken from the new location. Incomplete records were supplemented with weather data from the NOAA weather station located at Easterwood airport also in College Station, TX. Precipitation and potential evapotranspiration data were also drawn from these sources for use in the construction of the water budgets.

A dummy variable "study_group$_i$" was constructed to represent the groups that did and did not receive the water budget messages and coded 1=received the water budget messages and 0=did not receive the messages. Similarly, a time varying dummy variable "study_period$_t$" was created to represent the periods before and after the water budget program was implemented where 1=after beginning of the program and 0=before beginning of the program, as well as for each year during the treatment period (e.g. 2012, 2013, and 2014). An interaction term of "study_group" * "study_period" reveals the difference-in-difference in water use between the pseudo-control and the treatment group in the baseline period and the treatment period. Similarly, an interaction term for the study group and each of the individual years reveals the difference-in-difference for that year. In a similar study Ferraro and Miranda (2013) found the treatment effects of normative feedback experiments varied as a function of baseline water use. Following these results we also created three sub-groups to compare the treatment effect across levels of water use. We split households in the treatment group into equal thirds based on their mean monthly water use during the baseline period from 2008 to 2011. A demographic profile for households in the treatment and pseudo-control groups is presented in Table 7. Given that the households that were identified to receive the treatment were done so based on observed water use across the city, the treatment and pseudo control groups differ in terms of the distribution of demographic characteristics that have been shown to influence demand. Households in the treatment group on average used more water, were newer, larger, had larger lots, and were more valuable.

Table 7. Descriptive statistics for households in treatment and pseudo-control groups

Variable	Control (*M*)	Treatment (*M*)	Min.	Max.
Month Avg. Water Use (Th. Gal.)	10.32	14.32	1.023	90.471
Assessed Home Value ($)	180,792	255,227	87,200	982,380
Lot Size (acres)	0.282	0.295	0.101	2.04
Living Area (sqft)	1869.95	2404.38	1003	8584
Year Built (year)	1987	1995	1940	2008
Number of Households	4,561	4,255	-	-

Water use for the i^{th} household in month t is modeled to be a function of monthly precipitation and temperature, receipt of the water budget messages, and two sources of error. In the fixed-effects model an error term is estimated for each unit of observation. That is, each household has a source of error that can be decomposed to account for unobserved individual household characteristics. Decomposing the error term for each household allows for unbiased parameter estimates of the treatment effect (Wooldridge 2009). A description of model variables and their functional forms is presented in Table

8. All models were tested using the "xtreg" fixed effects package for panel data analysis in STATA 14 (StataCorp 2015). Variance estimates were adjusted to account for correlation in water use records for each household (Rogers 1993; Williams 2000).

Table 8. Description of model variables and units

Variable	Description	Units
water_use $_{i,t}$	Total monthly household water consumption	TH gallons
total_precip $_{t}$	Total monthly precipitation	Inches
ave_maxtemp $_{t}$	Average maximum daily air temperature	Degrees F
study_group $_{i}$	Household received water budget	0=No, 1=Yes
study_period $_{t}$	Month is part of the study period	0=No, 1=Yes
study_group $_{i}$ *study_period $_{t}$	Interaction of study group and study period difference in difference of monthly average water use	0=No, 1=Yes

Analysis and Results

Given the differences in demographic characteristics we first conducted a test of the parallel paths assumption. To test the assumption we compared the difference-in-difference in monthly water use for the group that would receive the water budget messages in 2012 and the pseudo-control for the years 2008 - 2009 as the baseline and the year 2010 as a comparison. If the two groups are indeed on parallel paths then we expect that there will not be a significant difference-in-difference between the groups between 2008-2009 and 2010 given that no treatment was administered in these years. We found that this was indeed the case (t = .49, p = .625). Following these results, we conducted our analysis in three stages designed to address our specific research questions presented below.

RQ1: Have the messages changed water use?

In our first model we compared the difference-in-difference in monthly irrigation season water use for the treatment group and the control for the baseline period 2008-2011 and 2012-2014 while controlling for monthly precipitation and monthly average maximum daily temperature. Summary effects for model one are presented in the first column of table 3. The effect for the variable study_group*study_period is the difference-in-difference variable which is interpreted as the treatment effect. The results indicate that the program has had a negative and statistically significant effect on water use for the households receiving the messages. On average households receiving the water budget messages reduced their water use by 634 gallons (t = -6.49, p <.001) per month, or roughly 3% over average monthly irrigation season water use during the baseline period. Additionally, we found that as precipitation increased by one inch per month average monthly water use fell by 303 gallons (t = -67.15, p <.001). Similarly, for every one degree increase in average monthly daily maximum air temperature water use increased by 972 gallons (t = 107.50, p <.001).

RQ2: How has water use changed overtime?

In our second set of models we separated out the treatment period into each of the three years 2012, 2013, and 2014 and estimated the difference-in-difference with the baseline period. Results for these three models are summarized in Table 9. For each of the three years the difference-in-difference was significant and negative. Additionally, the effect gets larger – i.e. more negative - moving from 2012 to 2014. The treatment effects were -489 (t = -4.56 p <.001), -618 (t = -5.20, p <.001), and -794 (t = -6.09, p <.001) gallons per month for 2012, 2013 and 2014 respectively. From 2012 to 2014 the strength of the treatment effect increased by roughly 305 gallons per month. The effects of daily average maximum air temperature on water use remain relative stable over time with coefficients of 985 (t = 106.17, p <.001) 962 (t = 108.61, p <.001) and 988 (t = 106.97, p <.001) for 2012, 2013, and 2014 respectively. Similarly, the effect of precipitation on water use remained relatively stable over time showing only a slight decrease for the pooled sample. Coefficients for precipitation were -438 (t = -70.85, p <.001), -429 (t = -71.57, p <.001) and -316 (t = -60.00, p <.001) for 2012, 2013, and 2014 respectively.

Table 9. Summary of effects of model predicting monthly water use for pooled sample and each year during study period

Variable	Full Period	2012	2013	2014
total_precip	**-0.303**(.00)***	**-0.438**(.01)***	**-0.429**(.01)***	**-0.316**(.00)***
ave_maxtemp	**0.972**(.00)***	**0.985**(.01)***	**0.962**(.01)***	**0.988**(.01)***
study_period	**-0.965**(.03)***	**-1.312**(.07)***	**-0.223**(.08)***	**-1.216**(.08)***
study_group* study_period	**-0.634**(.10)***	**-0.489**(.07)***	**-0.618**(.12)***	**-0.794**(.13)***
Constant	**-14.56**(.28)*******	**-14.62**(.29)*******	**-13.89**(.28)*******	**-15.04**(.29)*******
Observations	432,288	308,752	308,752	308,752
Overall R^2	0.11	0.11	0.12	0.12

*p≤.10, **p≤.05,***p≤.001

RQ3: Does the treatment effect vary by water use?

To test for variability in the treatment effect within the treatment group, we split the households that received the water budget messages into equal thirds based on water use during the period 2008-2011 and repeated the analyses in RQ1 and RQ2. We first tested three models comparing the difference-in-difference in water use for the bottom third, middle third, and top third of water using households in the treatment group for the treatment period as a whole. Results show that there was significant positive effect of the treatment on the bottom third of water users during the treatment period. That is, water users that fell in the bottom third during the baseline period significantly increased their water use by an average of 1,220 gallons (t = 11.39, p <.001) a month as a function of receiving the messages. Households falling in the middle third of water users during the baseline period showed a significant but small reduction in water use during the treatment period. On average households in the middle third group reduced their water use by 307 gallons a month (t = -2.52, p <.001). Last, households that fell in the top third of water users, as identified during the baseline period, showed a significant and large reduction in water use as a function of the treatment. On average these households reduced their monthly irrigation season consumption by 2,659 gallons (t = -15.74, p <.001). Results for these models are summarized in Table 10.

Table 10. Summary of effects of model predicting monthly water use by baseline water use groups

Variable	Bottom 33%	Middle 33%	Top 33%
total_precip	**-0.232** (.00)***	**-0.267** (.01)***	**-0.332** (.01)***
ave_maxtemp	**0.704** (.01)***	**0.826** (.01)***	**1.028** (.01)**
study_period	**-1.254** (.06)**	**-1.121** (.06)***	**-0.895** (.06)**
study_group* study_period	**1.220** (.12)***	**-0.307** (.07)**	**-2.659** (.17)**
Constant	**-9.762** (.29)***	**-11.837 (.29)***	**-15.189 (.39)***
Observations	291,589	291,638	296,705
Overall R^2	0.09	0.12	0.08

*p≤.10, **p≤.05,***p≤.001

Next we repeated these analyses for each of the three groups based on baseline water use (bottom third, middle third, and top third) for each of the three treatment years to examine change in the treatment effect for these groups over time. The results for the bottom third show an increase in the treatment effect over time, where these households use more water each year as a function of receiving the water budget messages, with average increases in monthly water use of 818 (t = 7.03, p <.001), 1,154 (t = 8.77, p <.001), and 1,687 (t = 11.87, p <.001) gallons for 2012, 2013, and 2014 respectively. The treatment effect for the middle group was found to be small and increasingly negative over time. In 2012 no significant treatment effect was found for the middle third group (M = -230, t = -1.60, p =.109). The treatment effect for the middle third group was small and marginally significant for 2013 (M = -318, t = -2.16, p = 0.031) and 2014 (M = -317, t = -2.34, p <.001). The top third of water users reduced their consumption by 1,942 gallons in 2012 (t = -10.26, p <.001), 2,543 gallons in 2013 (t = -11.96, p <.001) and 3,491 gallons in 2014 (t = -15.29, p <.001). Results for models examining the treatment effect by group through time are summarized in Table 11. Only the difference-in-difference coefficient is displayed.

Table 11. Summary of effects of model predicting monthly water use by baseline water use group by year

Group	2012	2013	2014
Bottom 33	**0.818**(.12)***	**1.154**(.13)***	**1.687**(.14)***
Middle 33%	**-0.230**(.14)	**-0.319**(.15)**	**-0.372**(.16)**
Top 33%	**-1.942**(.19)***	**-2.543**(.21)***	**-3.491**(.23)***

*p≤.10, **p≤.05,***p≤.001

Discussion

Efficacy of the Water Budget Program

The water budget program was successful in creating a change in water use among message recipients. We found that over the course of the entire treatment period message recipients reduced their monthly consumption by 3% or roughly 634 gallons per month compared to the period before the messages were administered. The magnitude of reduction in monthly average water use that we achieved as a function of the program is consistent much of the past work in social psychology and behavioral economics that has taken a norms-based approach to behavior change in an experimental context in residential water conservation (Bernedo et al. 2014). Ferraro et al. (2011), for example, found that water customers reduced their consumption by 4.8% as a function of receiving an educational message with a social normative comparison. In a review of the residential energy conservation literature employing norms-based messages, Alcott (2011) found that treatment effects ranged from 1.4% – 3.3% of monthly consumption. These results further support the utility of normative feedback approaches for achieving changes in consumer behavior, but highlight the heterogeneity in the context in which they occur.

Extrapolated over the treatment period (21 months of irrigation season) a 3% reduction in monthly household water use for the entire treatment group (n=5,565) yields a savings of over 75,000,000 gallons or roughly 77 acre feet per year. However, city water planning projections show that by 2060 the utility will have an unmet annual water need of roughly 5,600 acre feet. This suggests that although the program was successful in achieving a change in water use more will need to be done to meet rising demands.

Variability in the Treatment Effect over Time

The observed reduction in monthly water use for our treatment group was stronger with each year during the treatment period. In 2012 during the first irrigation season after the administration of the messages we observed a reduction in water use of 489 gallons per month. The treatment effect increased – i.e. was more negative – in both 2013 and 2014 among treatment households. From 2012 to 2014 the strength of the reduction in monthly water use increased by 38% to roughly 794 gallons per month (t=-6.09, p=0.000). Although we only have three years of data, the trajectory of this trend suggests that it may persist into the future if the program is continued. To the best of our knowledge this is the first study to document an increase in a treatment effect following the administration and repetition of norms-based feedback information of this nature in the context of residential water use. Alcott and Rodgers (2012) investigated the effects of the repetition of norms-based messages on residential energy use. They found that energy savings do increase with the repetition of messages like social normative comparisons, but that the effects of these messages attenuate over time if they are discontinued. Similarly, Bernedo et al. (2014) demonstrated that social normative messages can have a statistically significant impact on water use six years after the administration of the treatment. However, in their work they found that the effect of the treatment declines with each year after administration. In fact, three years after the administration of their messages, Bernedo et al., (2014) observed a less than 2% reduction in monthly water use. Our results suggest that there is some added value to providing consumers with feedback information more than just once, and mirror findings from Alcott and Rodgers (2012) on residential energy use. Not only can the repetition of norms-based messages stop the attenuation of the treatment effect, but it can result in an increase. The ceiling for this trend, however, remains to be found.

Variability Between Groups and Over Time

Past work has demonstrated that the effects of norms-based messages on residential water use can vary as a function of baseline consumption. Ferraro and Miranda (2013), for instance, demonstrated that treatment effects of social norms messages were strongest among the highest consuming households in their sample. Our results are in-line with this finding. In our study the households falling into the top one third of water consumers during the baseline period showed a large and statistically significant reduction in water use during the treatment period. These results are contrasted by an observed increase in water use among the bottom third of water using households. Schultz et al., (2007) warn of the dangers of providing descriptive normative information without a statement that approves or disapproves of the individual's current behavior; referred to as an injunctive norm. If the injunctive norm concerning what is appropriate behavior is not clear then the outcome may be an increase in an undesirable behavior. This is likely what is occurring within the context of our study. Research in health communication, for example, has shown that providing youth with descriptive information concerning alcohol use without a sufficient statement concerning what is appropriate can cause in increase in alcohol consumption (Prince et al. 2014; Ringold 2002). Households using less water than the water budget recommends may be interpreting the message to mean that they should increase their consumption in order to keep their lawn healthy. Past work has termed the phenomena the "boomerang effect" or the "magnetic middle" (Schultz et al. 2007). This finding has implications for practice. The structure of the message and the households that receive it has bearing on the outcome. We suggest, in the future, that messages are sent only to the top third of water using households, or that the injunctive message is substantially altered to reflect the intention of the utility in administering the messages in the first place. However, it should be noted that the reductions in water use achieved in the middle third and top third group far outweigh the increases observed in the bottom. These results also highlight the importance of conducting empirical evaluations of conservation programs.

Not all of the policy instruments that are implemented to influence consumer behavior will be useful, cost effective, equitable, or well received by the public. Determining which ones are effective in bringing about a change in consumer behavior will lead to better conservation results (Ferraro and Pattanayak 2006).

In addition to observing differences in the directionality and strength of the messages' effects on water use across the three groups, we also observed differences over time. For the top third and bottom third of water users the strength of the treatment effect increases with each year that it is administered. The middle third group shows a limited response to the message either positive or negative that remains relative stable from 2012 to 2014. These results further suggest that the top user group within the sample should be targeted for further interventions and that the messages content has had meaningful impact on water use.

Limitations

One of the major limiting factors in conservation program evaluation is the ability to draw causal inference from counterfactual changes in the outcome of interest. (Ferraro and Pattanayak 2006). The difference-in-difference model that was used in the current study is one way to get around the non-experimental nature of the study and attribute a treatment effect to the information-based program. However, there are a number of limitations to this design and our study moreover that should be noted. Selection bias is possible given that the treatment group was recruited because of its high water use. Observed changes in water use can be attributed to the treatment or *may* be a function of differences in endogenous factor that contribute to demand – i.e. lot size, income, number of residents, between the two groups (Ferraro and Pattanayak 2006). However, we are able to test for this bias. Our examination of the parallel paths assumption indicates that there was no difference-in-difference in water use in the period before the treatment occurred leading us to conclude that the assumption holds and that the causal inference is valid.

Implications for Practice

Behavioral interventions are becoming an increasingly popular mechanism to achieve reductions in resource use in both the natural resource sector and as a social policy instrument moreover (Thaler and Sustein 2008; Ferraro and Miranda 2013). Understanding the variability in individual responses to social norms messages is important to hone message design and anticipate the outcomes of behavior change initiatives. Messages that fail to present an adequate injunctive statement can have unintended and often deleterious consequences (Shultz et al. 2007). In the context of our study we suggest that managers re-assess the content of the water budget messages as it pertains to the injunctive statement and limit who receives it to only the top water users within the sample. Utilities exploring norms-based behavior change approaches for residential water conservation should take caution in the specific way that messages are designed and implemented. We documented an increase in water use among the lowest consuming households in our sample. If these households did not receive the messages we expect that the impacts of the program as a whole would have been much more pronounced.

Changing patterns of residential water use requires both behavioral adjustments and investment in infrastructure at the household scale (Alcott and Rodgers 2012; Ferraro et al. 2011). The extent to which the reductions in water use that we observed are due to either changes in behavior or changes to infrastructure remains unclear. Further work is needed to clarify this distinction. Although short term behavioral changes might be possible to motivate with social normative messages like those employed by the water budget program, the extent to which they have lasting impacts on water use remains unclear. If the program has motivated households to make investments in infrastructure to improve efficiency of their outdoor water use we expect that the impacts of the program will persist even if no more messages are sent. If these changes are the result of behavioral adjustments (i.e. shutting off irrigation system after rain) their lasting impacts may be far less pronounced.

We encourage water utilities to explore norms-based messaging as option for influencing residential demand. The results of this study, and several others, indicate that normative approaches to behavior change are effective mechanisms for conservation. Meeting growing residential demands in places like Texas will require creative solutions like the water budget program.

CONCULSIONS

If water managers wish to achieve desired reductions in patterns of residential water use, they must first understand the factors that influence household water use decisions. Knowledge of the factors that influence water use decisions will lay the groundwork for understanding the efficacy of policy instruments adopted in an effort to change them. This is especially the case for voluntary information-based mechanisms that seek to alter consumer attitudes and behaviors (Mckenzie-Mohr 2000). Understanding consumer attitudes toward complying with behaviors advocated by persuasive information-based instruments is critical in order to design policy that effectively influences household water use (Syme et al. 2000).

In this research I examined the efficacy of one such policy instrument. The results indicate that the program was successful in developing positive attitudes toward complying with the water budget, and that those attitudes play a significant role in outdoor water use decisions. However, attitudinal factors exert relatively less influence on compliance with the water budget than aspects of the environmental context including, irrigable area of the lawn, and income. These results have important implications for both theory and practice. The theoretical model on which this research was based was confirmed and extended to demonstrate the relevant factors that facilitate and constrain consumers from acting on positive attitudes toward complying with conservation policy. In addition to extending knowledge of the attitude-behavior relationship in the context of residential water use, this information informs the administration of persuasive instruments to residential consumers by identifying which factors should be targeted for interventions.

Next, I explored the relationship between community attachment, personal water conservation norms, and residential outdoor water use. Results of this work indicate that one’s attachment to the community is an important, but until now overlooked, aspect of the internalization of an obligation to conserve community resources. These findings extend theory to consider the relationship between the individual and the broader community as an important factor guiding behaviors that have implications for the community. Community development, therefore, is a potential avenue for developing affective attachments to community, and fostering personal norms that lead to the self-regulation of behaviors that positively influence community resources.

Last, I tested the effects of the administration of the water budget communications on household water use. In this work I found that the households that received the water budgets exhibited a significant change in consumption as a function of the program. This finding adds to a small body of work that has demonstrated the effects of persuasive instruments on metered household water use (Ferraro et al 2014). Additionally, I found that the treatment effect varies as a function of water use, and strengthens over time. In fact, I found that water use increased as a function of the program among households that were in the lowest water use group in the period before the messages were administered. These findings reiterate work in psychology stemming from social comparison theory (Festinger 1954) and have important implications for practice.

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